NATIONALGEOGRAPHIC.COM/MAGAZINE | **SEPTEMBER 2008**

NATIONAL GEOGRAPHIC

WHERE FOOD BEGINS

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When Mom was my age, there weren't many ways to prepare financially for what was coming. You just had to work hard, save what you could and hope for the best. So here I am, taking care of my mom and my kids at the same time. I've never worked so hard, or stretched a dollar so far.

Today you can prepare for what's coming. And we have. Our insurance will help take care of our bills later in life so our kids won't have to. So, even though some days I fall into bed exhausted, I sleep well.

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Narrow-striped Mongoose *(Mungotictis decemlineata)*
Size: Head and body length, 25 - 35 cm (9.9 - 13.8 inches); tail, 20 - 27 cm (7.9 - 10.6 inches)
Weight: 600 - 700 g (1.3 - 1.5 lbs) **Habitat:** Western Madagascar; prefers dry seasonal forests
Surviving number: Estimated at 8,400 - 12,050

Photographed by Nick Garbutt

WILDLIFE AS CANON SEES IT

Let it rain. Worms, insects and other tasty morsels are easy to find during the wet season, so the narrow-striped mongoose has the resources to live in groups of six to eight. Sharing a home range, they spend most of their time in the trees and sleep in tree holes at night. As food becomes more elusive with the coming of dry season, they break into smaller groups, forage more on the ground and sleep in burrows. Wet or dry, vocalizations in the form of short, repeated calls help keep the group together. But dangers threaten to tear their lives apart, from the destruction of the forest to harassment by a deadly new neighbor: domesticated dogs gone feral.

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NATIONAL GEOGRAPHIC

SEPTEMBER 2008 • VOL. 214 • NO. 3

PAUL NICKLEN

Special cells allow sailfish to change color quickly—from silver to bronze to black—which may help confuse their prey. Story on page 70.

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

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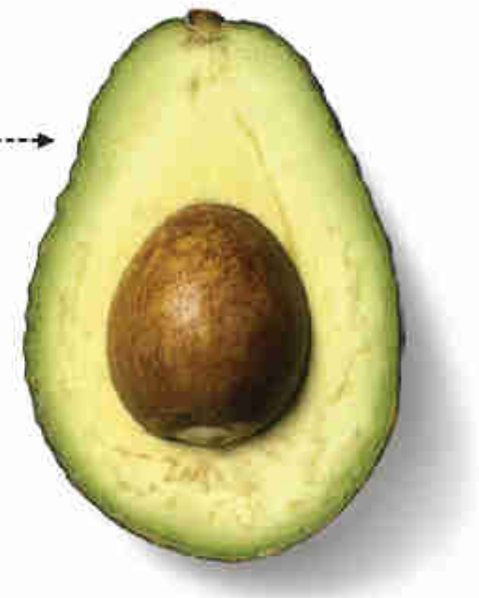
SEPTEMBER 2008



On the Cover

Regular garden soil nurtured this 12-day-old soybean plant.

Photo by Mark Thiessen, NG Photographer

ngm.com

Digital Dilemmas

You just bought a digital camera and aren't sure what memory card to use. Photojournalist Ken Geiger has advice on this and other topics in his Digital Photography blog.

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Remember all the stupid things you did behind the wheel when you were a teenager?

NOW ADD A CELL PHONE, A VANILLA SOY LATTE AND AN MP3 PLAYER.

Whether texting, drinking or scrolling through songs, multitasking doubles the risk of having an accident.[1]

Allstate believes there are ways we can help teens curb many of their dangerous driving behaviors:

BAN DIGITAL DISTRACTIONS.
Legislation banning some distractions can help discourage teen multitasking. The State of California has now banned anyone under the age of 18 from using cell phones, laptop computers, pagers or any text-messaging device while driving, except in the case of an emergency.

PUT LIMITS ON TEEN DRIVING.
Graduated Driver Licensing (GDL) laws restrict teen driving so kids can gain experience safely. Since North Carolina implemented one of the most comprehensive GDL laws in the country, it has seen a 25% decline in crashes involving 16-year-olds.

HAVE THE DRIVING TALK.
It may be surprising, but 75% of teens said their parents would be the best influence in getting them to drive more safely.[2] The Allstate Parent-Teen Driving Contract can help start the conversation about many driving behaviors, including multitasking. **Contact an Allstate Agent to get a copy or visit Allstate.com/teen for the interactive contract.**

Let's help teens shift their driving behaviors.

It's time to make the world a safer place to drive.
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[1]NHTSA 100 Car Driving Study, 2006. [2]The Allstate Foundation Report on Teen Driving, 2005.

EDITOR'S NOTE

A bull elephant browses trees in Tanzania's Ngorongoro Crater. He later investigated the Editor's Land Rover.

Elephants stir strong emotions. I remember standing in the roof hatch of a Land Rover to photograph a bull elephant in Tanzania. The animal turned, headed toward me, and laid his tusks on the hood. I slid down and froze as his trunk slipped through the hatch and paused, inches from my face. Gently, the tip tapped my left shoulder and snuffled my neck. His warm breath filled the Rover. Then he retracted his trunk and ambled off. The contact took my breath away.

Years later, I had an encounter that left me with a different emotion. I was in a helicopter chasing a large bull in South Africa's Kruger National Park. As the pilot brought us in behind the frantic elephant, a ranger, Douw Grobler, leaned out and fired a bullet into the animal's head. He collapsed, driving his tusks deep into the dust. "A perfect brain shot," Grobler said, adding that he did it "only to protect the park's biodiversity. I wish there were a better way." Sadly, sometimes there are too many elephants, even in the vastness of Kruger. The ranger was simply doing his job as part of a culling operation.

A passionate advocate of African elephants is zoologist Iain Douglas-Hamilton. For more than a year, he worked with photographer Michael Nichols and writer David Quammen to bring you this issue's coverage of the elephants of Samburu National Reserve area in Kenya. It's a heartening story, but elsewhere the situation is more complicated. After 13 years, South Africa has lifted its moratorium on culling. This month we also examine that decision and the debate it provokes.

PHOTO: CHRIS JOHNS, NATIONAL GEOGRAPHIC IMAGE COLLECTION

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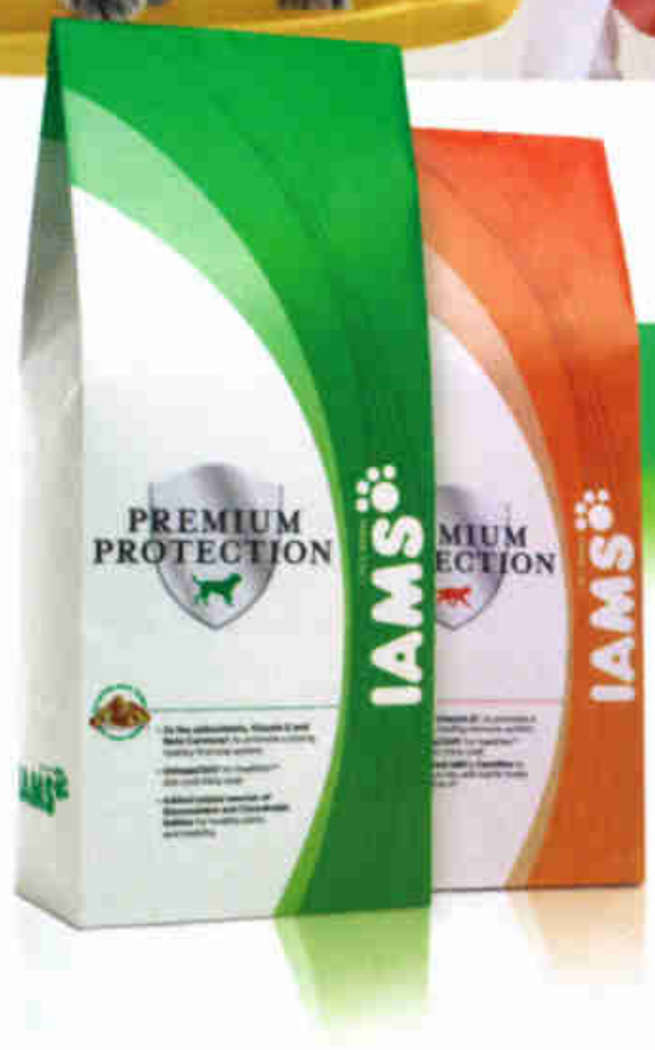
Dr. Katy J. Nelson
Alexandria, VA



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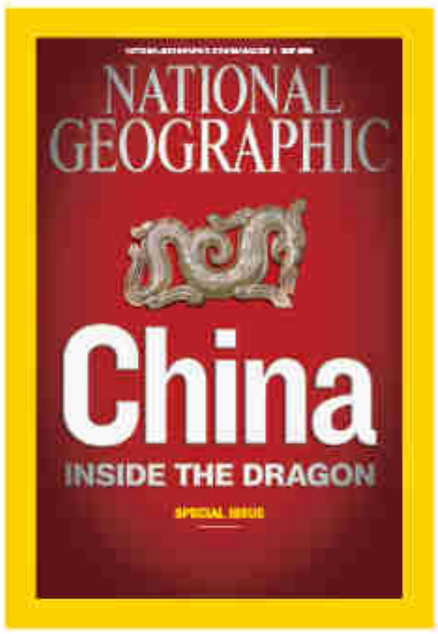
LETTERS



May 2008

China: Inside the Dragon

Thank you for the excellent coverage of the good, the bad, and the ugly about China without judging, condemning, or demonizing the country.

HAT LAU
Palm Coast, Florida

I have never read a magazine cover to cover—not until "China: Inside the Dragon" arrived in my mailbox. Fascinating. Beautiful. I wished for more. Alas, there simply weren't enough pages!

CAROL FREELAND
Lees Summit, Missouri

What a waste of time and my money. I subscribe to read about diverse issues in the world, not just about China.

BRUCE KOPETZ
West Bloomfield, Michigan

In 1988 I was a 19-year-old American student in Hangzhou, China. The doors were "open," but no one really had come through them yet. I remember thinking, if everyone here lives like Americans, the planet is screwed. The photo of the suburbs is my prophetic nightmare realized.

JASON A. LONG
North Oaks, Minnesota

By failing to include anything more than a few vague images and incomplete words on the Tibetan struggle, your presentation of China is disappointing. You deny the reality of millions of Tibetans living under the occupation and human rights abuses of the Chinese government.

DANA PETERSON
Shrewsbury, Pennsylvania

Just back from a nostalgic trip to western China, 83 years after I was born and raised there in a Canadian missionary family. I am pleased to see the multidimensional picture of China, especially the striking portrayal of capitalist economic growth and environmental destruction. Some people may object to your map portraying Tibet as part of China, although maps worldwide have done this since long before the Communist regime.

DONALD WILLMOTT
Owen Sound, Ontario

Your map shows Tibet as a province of China. Tibet is widely recognized as a sovereign nation. The violent invasion, unlawful occupation, and brutal repression of over half a century does not in any way change that. I hope you consider issuing a geographically and historically accurate map.

DANIEL SEYMOUR
Rolling Meadows, Illinois

You will no doubt receive grief for your reporting on Tibet. The bare fact is that China does have a historical claim. But it would be an understatement to say the Chinese presence is insensitive to local traditions. What is called for is considerable soul-searching by the Chinese and a good faith effort by all sides to arrive at an accommodation.

DICK SNYDER
San Diego, California

My eyes at first did not see the "disclaimer" on the supplement map regarding Taiwan. That's a good first step, to print a disclaimer in fine print to tell readers there is some controversy in the world regarding whether Taiwan is a part of China, or China a part of Taiwan. Still, couldn't the map show the two countries in different colors, with the disclaimer saying that while Taiwan considers itself a separate country, China considers it part of the motherland?

DAN BLOOM
Chiayi City, Taiwan

The issue of the sovereignty of Taiwan as distinct from mainland China is complex. The People's Republic of China claims sovereignty over Taiwan. While Taiwan functions independently, its government has never formalized independence, and Taiwan is not recognized as independent by the United Nations or most countries, including the United States.

Although Tibet was autonomous for much of the first half of the 20th century, it is now part of the People's Republic of China. Our map policy is to reflect the reality on the ground.

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LETTERS

Please don't paint China as such a beautiful place when its leaders are doing their best to destroy it via environmental terrorism and crimes against humanity.

TERRY L. LIKENS
Seattle, Washington

Very scary! The Chinese are killing their country one ruined river, one greedy official, one cancer-ridden village, one environmental disaster at a time.

BARBARA TAYLOR
Santa Rosa, California

After reading this issue, I feel I've looked into the face of our doom. For the rush of the dollar, China will bring the world to its ecological knees. Instead of learning from mistakes of the past, it's repeating the very same ones.

GARY PIDA
Canyon Country, California

Amy Tan's description of life in the Dong village of Dimen ("Village on the Edge of Time") rings true. Only one 74-year-old woman still knows the epic song about the history of Dimen. Tan despairs that the Dong people have no written form of their language, Kam, to preserve such songs. There is, however, a written form of Dong, commissioned by the Chinese government in the 1950s. A pilot program in the Dong village of Zaidang involves instruction in both Mandarin and Dong. The main goal is to improve levels of Mandarin; an obvious spin-off is strengthening Dong culture.

NORMAN GEARY
Dong/Mandarin Bilingual Project
Bangor, Northern Ireland

How sad to see so many Chinese carried away with the American model of consumerism, with its empty glitz and glitter. Yet with rich Eastern philosophical roots almost part of their DNA, they may yet apply the brakes and point this truly rich society in new directions.

WILLIAM H. WHITE
Fort Walton Beach, Florida

I feel I've looked into the face of our doom. For the rush of the dollar, China will bring the world to its ecological knees. Instead of learning from mistakes of the past, it's repeating the very same ones.

While China may be the next superpower, I found it disheartening to see the Chinese are no further ahead in compassion for other species than we are: the fur with paws, netted monkeys for experiments, live crocodiles displayed in lush hotel lobbies for someone's dinner.

G. A. CUMMINGS
Salem, Oregon

Seems to me China is quickly self-destructing from both a human and environmental standpoint due to its manufacturing excesses. The "coming out" party of the Olympics may well be this culture's apex.

PETE WILLIAMS
Prescott, Arizona

Visiting China in 1983, 1985, and 1987, I saw some free enterprise: Peasants sold straw hats, terra-cotta soldier figures were replicated, street vendors made shirts to order. It was impossible to imagine the manufacturing progress of the next two decades. What brought about this surge? My brother, who worked at the University of Massachusetts Amherst from the 1960s to the 1980s, saw hundreds of diligent Chinese students. That generation of students who went abroad have made China what it is today.

ARTHUR H. GERHARDT
Albany, New York

"The Road Ahead" was a fitting end to the issue. Our Western consumption patterns are the elephant in the room. We are addicted to Asian-made goods but angrily criticize China's CO_2 emissions and horrifying pollution. Just as we outsource production to China, we are outsourcing massive environmental problems.

JANIE BOOTH
Davis, California

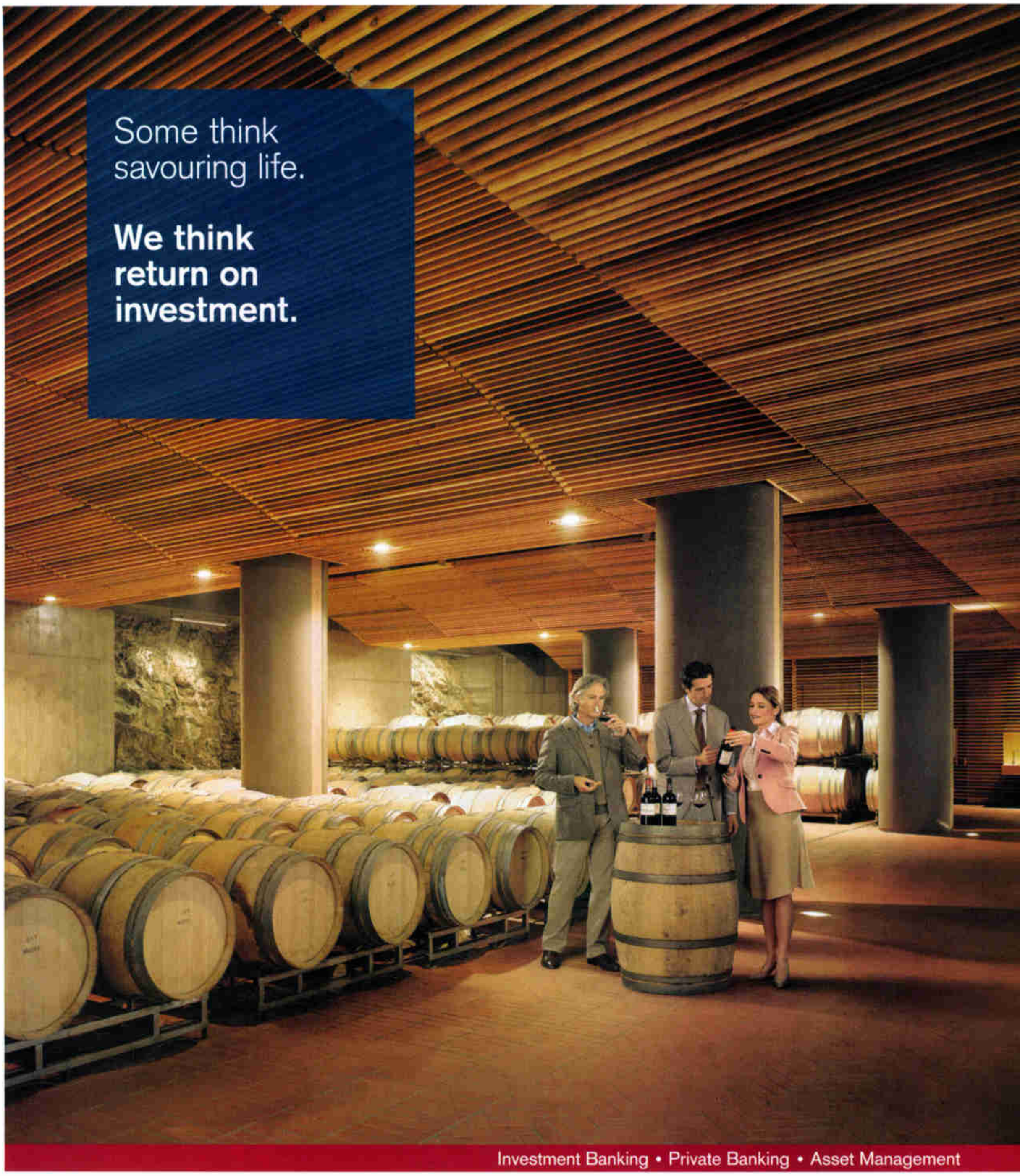
Corrections, Clarifications

May 2008:
Special Supplement:
China/Forbidden City
The description of the People's Republic of China as the "fourth largest country, only slightly smaller than the United States," is based on land and inland-water area and excludes Taiwan.

Construction of the Grand Canal began in the fifth century B.C.

The end of the Qianlong emperor's reign was 1796.

Olympic Torch Run
A late change in the route added Delhi and cut out Mumbai.



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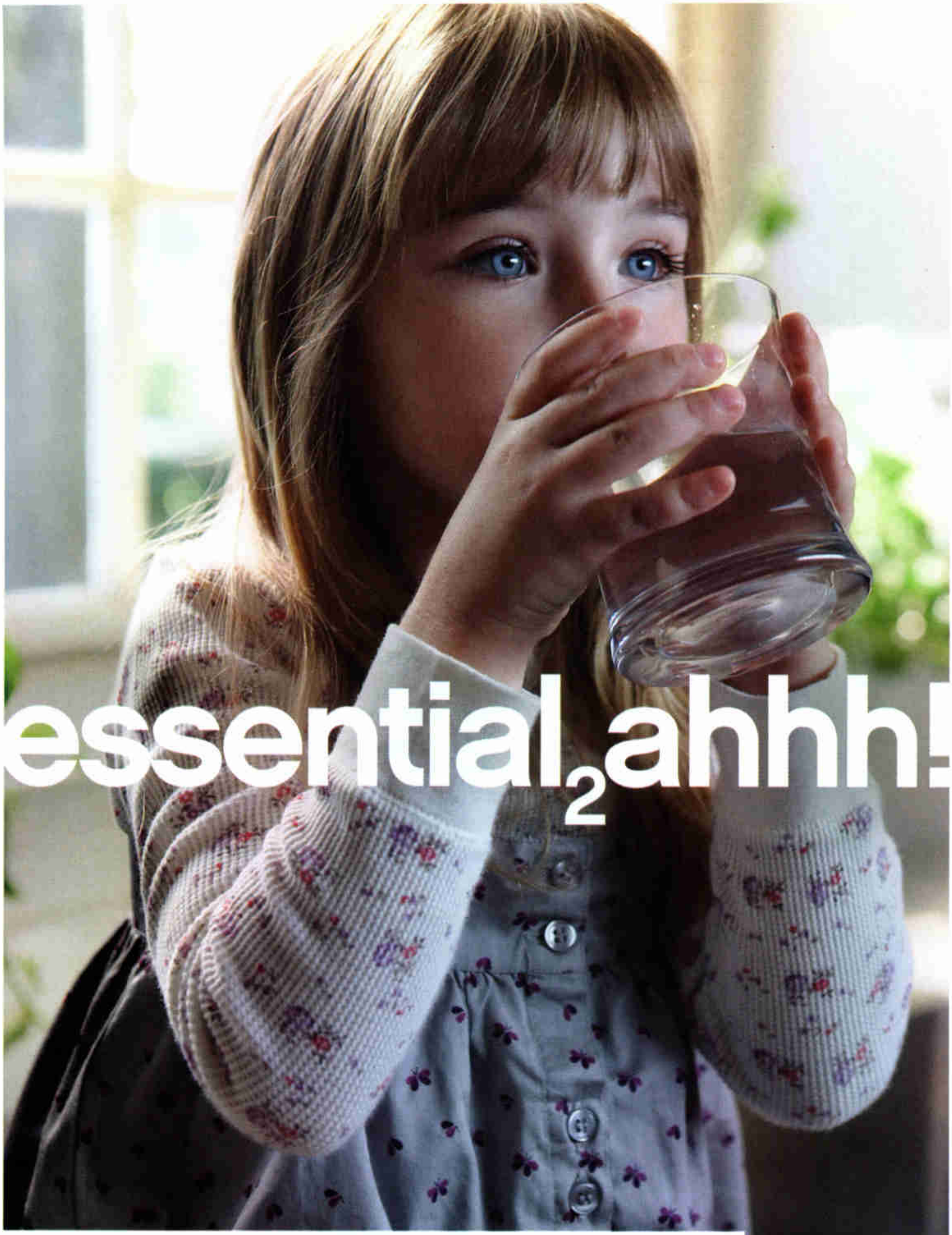
Winning Ways Your photos are getting Your Shot a lot of recognition lately. We took honors for best use of photography at this year's Webby Awards, and the Magazine Publishers of America awarded our puzzle generator first place in its digital awards for best Web-only tool. Your Shot itself took third place for best online community. It's easy to join Your Shot. For guidelines and more information go to *ngm.com/yourshot.*

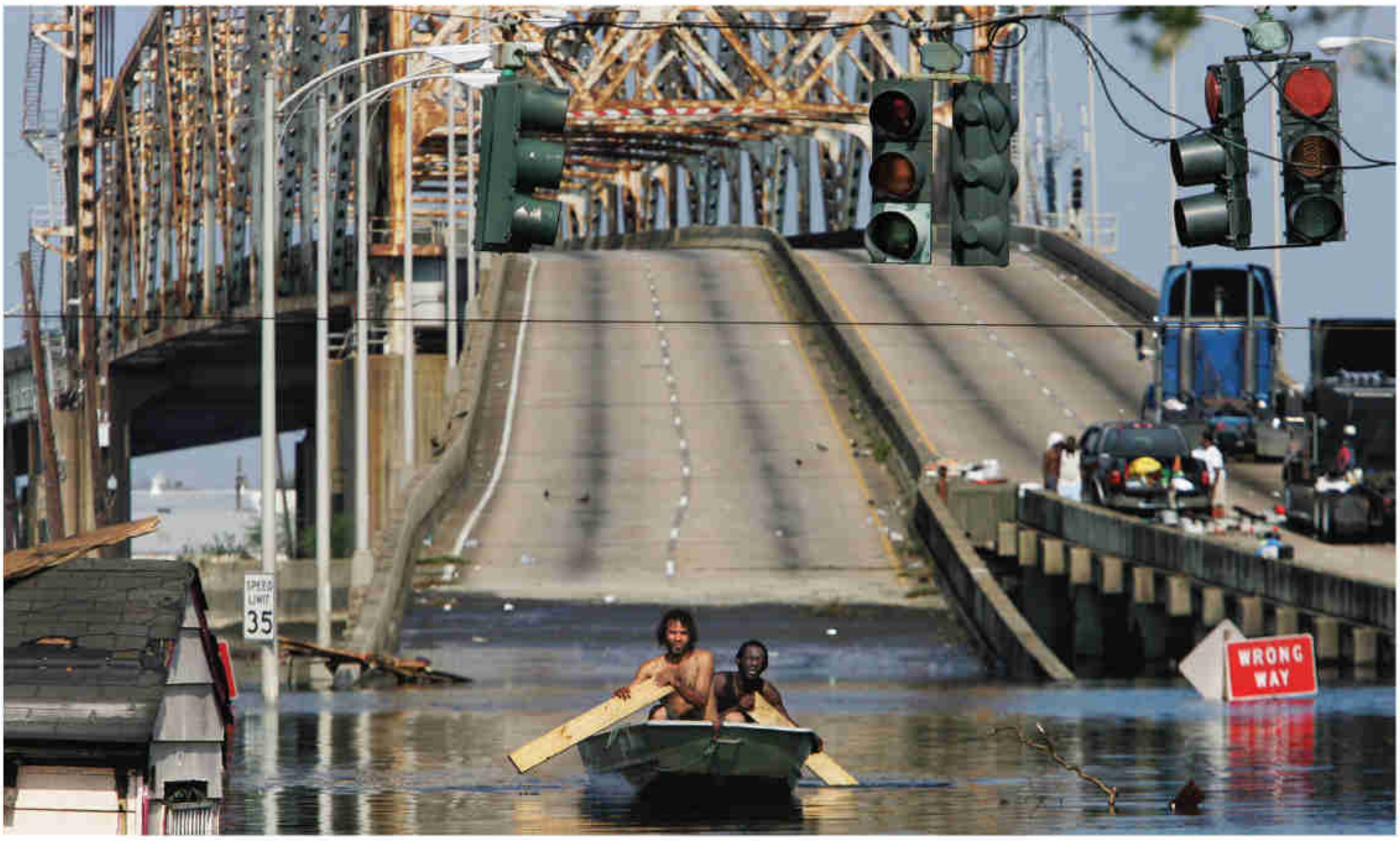
Vito Ottomano Singapore

"I had two dreams in life—to become a professional pilot and to photograph for *National Geographic,*" says Italian-born Vito Ottomano, 34, who flies 747s for a living. On a layover in Dublin he snapped these high-heeled women mid-stride—and fulfilled his second dream.

Victor Cerutti Paris, France

A sleepy sea lion caught the eye of Victor Cerutti during a vacation to the Galápagos Islands last year. "It was quite easy to take good photos there," says the 24-year-old Web developer. This photo was voted an *ngm.com* audience favorite.





Claiborne Avenue Bridge, Lower Ninth Ward

AUGUST 31, 2005 These men weathered Katrina in their truck and spent two days on the bridge before somehow finding a boat. They paddled toward me, asking for food.

MARCH 14, 2008 Cars stream in and out of the Lower Ninth Ward.

New Orleans: Then and Now

I arrived in New Orleans a day and a half before Katrina did. The hurricane was gathering strength in the Gulf of Mexico, and my photo agency thought it would be good to have somebody in place down there. The airport was almost out of rental cars by the time I got there on Saturday afternoon. All they had for me was a mint green Toyota. I ended up sleeping in that car part of the time—and I was still better off than a lot of the people I saw over the next few days. I've been back to New Orleans about a dozen times since 2005. I hope in some small way my photographs will remind people that this treasure of a city was nearly washed away and continues—in some places, anyway—to hang by a thread. Despite the forces of nature and governmental ineptitude, New Orleans is still trying to rebuild. It needs all the help it can get.

night night. lights out. hey this thing goes all the way flat. now i can sleep on my side. on my other side. on my - what's this? a duvet? what's a duvet? i don't know but man it's soft. and this pillow is plush. did i just say 'plush'?

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Saint Patrick Cemetery, Port Sulphur

SEPTEMBER 11, 2005 It was nearly two weeks before the roads opened and I could drive down to Port Sulphur, a town south of New Orleans in Plaquemines Parish. I waded through the water to get this picture, and I remember the motion of the waves lapping around me.

MARCH 20, 2008 I was glad to come back and see that all the graves were intact after the floodwater receded. This is such a beautiful, peaceful place.

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Columbus Street, Seventh Ward

SEPTEMBER 6, 2005 This man—everybody just called him "Cowboy"—had taken shelter in the home that went up in flames. All he salvaged before escaping was a whiskey bottle and a weed whacker. The landlord, who'd grown up in that house, never saw him again.

MARCH 18, 2008 The burned house hasn't yet been rebuilt, but neighborhood life goes on. There's a school across the street; I shot this as kids were getting out at the end of the day.

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Burgundy Street, French Quarter

AUGUST 29, 2005 The bricks scattered across the road in this residential area were the result of high winds. This was the most damage I saw in the French Quarter, which is on higher ground and didn't get the flooding that did so much damage elsewhere in New Orleans.

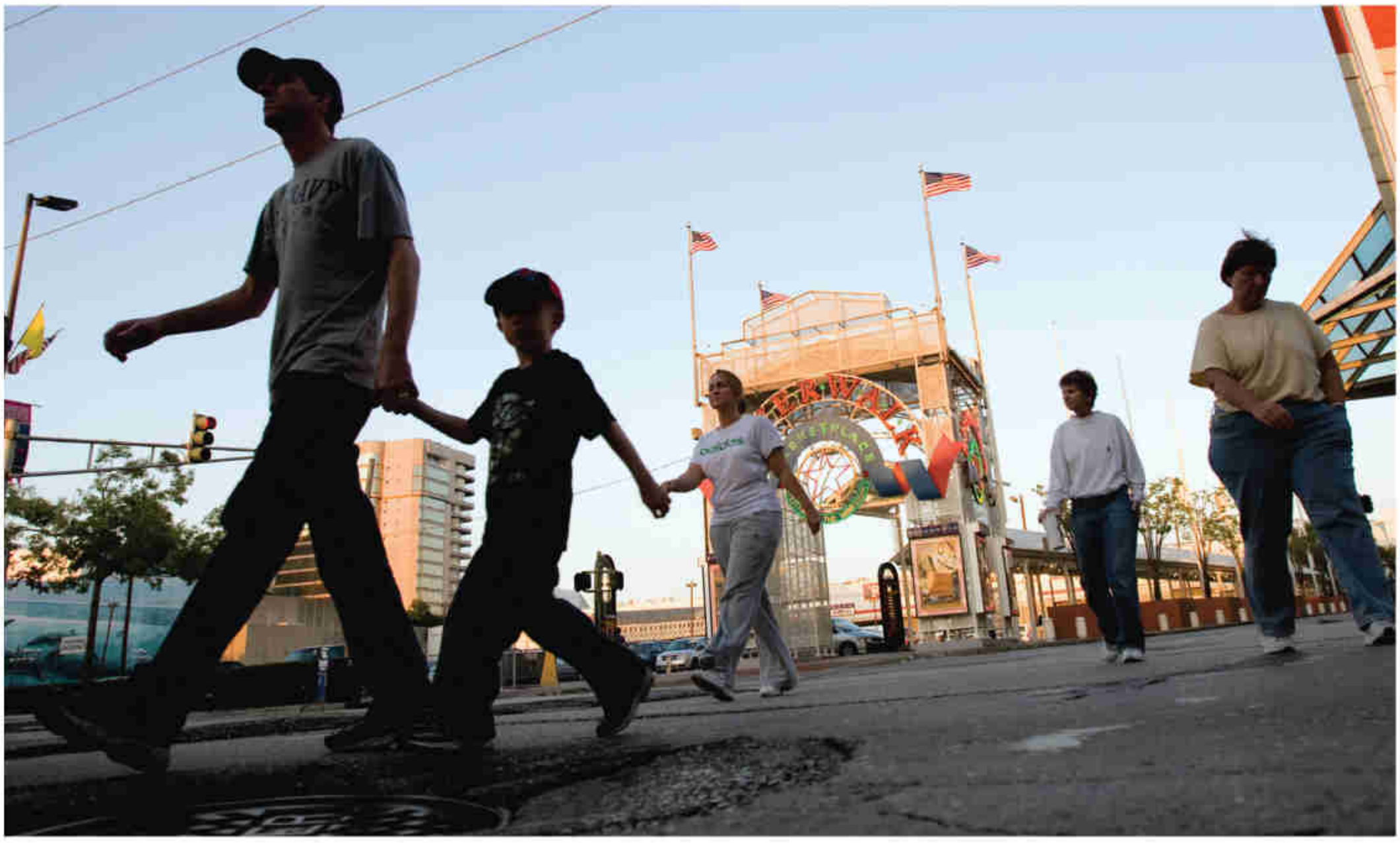
MARCH 20, 2008 The debris may have long been cleared away, but the brick wall that collapsed here still hasn't been repaired.

PHOTO JOURNAL | MARIO TAMA

Riverwalk, near Morial Convention Center

SEPTEMBER 2, 2005 I'd photographed the lady in the wheelchair being evacuated from a nursing home a few days earlier. I was surprised to see her again. Thousands gathered at the convention center after the storm, but there was no electric power, no food, no sanitation. This was the day that the National Guard responded; they were moving people into the shade to cool off.

MARCH 23, 2008 Riverwalk is attracting tourists once again.



Mario Tama is a Getty Images photographer. To learn more about rebuilding New Orleans, see neworleans.acorn.org.

THE LAWS OF GRAVITY DON'T APPLY TO EUPHORIA.

My leash is broken. Nothing can keep me d
I can't find that kind of f
There's an e

Page, Arizona

beaten path with everything
makes this place and I a perfect fit
together. Nature can't be put on a leash, either.

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Maldives A school of snorkelers struggle to keep pace with a whale shark—the world's biggest fish, which can grow more than 60 feet long. These rare sharks glide along swiftly, exhausting even fit swimmers within minutes.

PHOTO: MANU SAN FÉLIX

Cerro de Sorte, Venezuela Surrounded by candles symbolizing regeneration, followers of a cult centered on the local goddess María Lionza wait for cleansing during an hour-long ritual.

PHOTO: CRISTINA GARCÍA RODERO, MAGNUM PHOTOS

Kiev, Ukraine Dwarfed by the memory of her nation's past, a woman at the National Museum of History of the Great Patriotic War adjusts her outfit in front of a monument to Soviet soldiers.

See more Visions of Earth images at **visionsofearth.ngm.com.**

PHOTO: SERGEI SUPINSKY, AFP/GETTY IMAGES

GOOD Decisions

#1 *in a Series*

ANNIE Griffiths Belt

HER Camera, HER Kids

> Taking *my children* with me on assignment was the *best decision* of my career.

Keeping family in focus has always been a top priority for National Geographic photographer Annie Griffiths Belt. While most globe-trotting photographers are forced to spend large chunks of time away from their children, Belt made the decision to take her kids on the road during her assignments. Her new book, *A Camera, Two Kids and a Camel* (National Geographic), a photo memoir, depicts her stunning photography alongside stories of the rich, unusual life she created for her family.

Belt decided to meld her two worlds even before she had her children, Lily and Charlie, now grown. "I was once out to dinner with a colleague in Washington, D.C.—a man who had a magnificent career—and I asked him if there was anything he would do differently, and he said yes, he would have taken his kids along. He regretted that he didn't spend more time with them. I really took that to heart," says Belt.

As a result of her decision, her children—along with millions of readers—have found inspiration from her award-winning work and learned to truly care about the world. "Over the last ten years my pictures have been used for aid organizations, for environmental causes, and that's been the biggest joy for me—that my photography has a life of its own, that it's touching other people's lives. What's better than that?"

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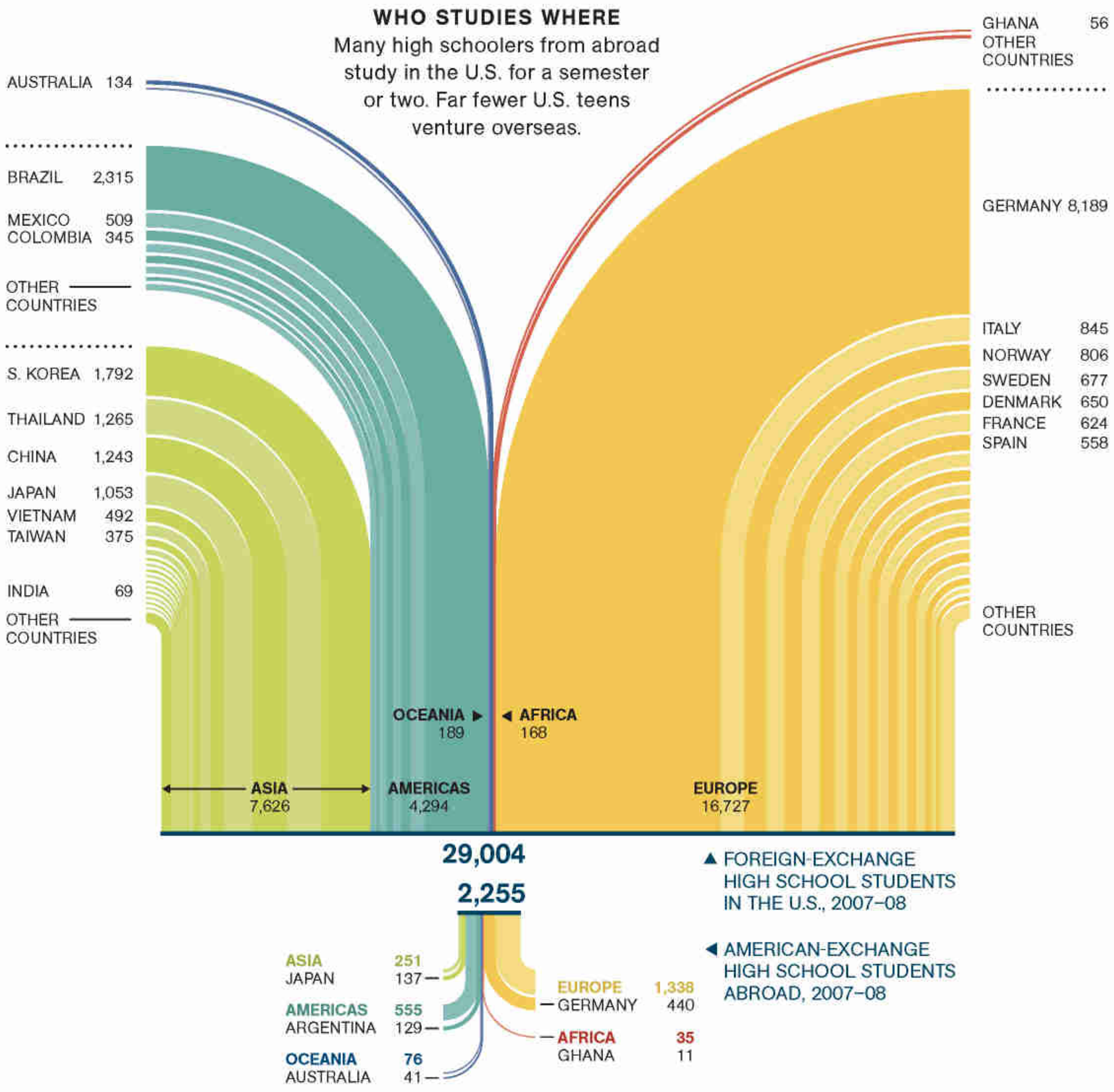

High School Give-and-Take

Five Oregon 11th graders balk at working with an Arab exchange student who's a Muslim. Another Muslim exchange student, Hina Saifi of India, sees the impasse and helps her classmate explain: Islam is not a religion of terror. In the end, the teens all "became close friends," says Saifi, who was touched to see Americans open "hearts and homes" to her this past school year. That kind of attitude flip was the goal in 1947, when World War II ambulance drivers from the American Field Service pioneered a high school exchange effort known as AFS. Germany has long been a big player, initially motivated by a desire to do postwar outreach. In the post-9/11 world, U.S. groups hope to welcome more Muslims and ease their culture shock. Since Americans can be a tad parochial, the Council on Standards for International Educational Travel is wooing them as students and as host families. *—Marc Silver*

Learn more about exchange programs at **ngm.com.**

ART: SEAN MCNAUGHTON, NG STAFF. SOURCE: COUNCIL ON STANDARDS FOR INTERNATIONAL EDUCATIONAL TRAVEL

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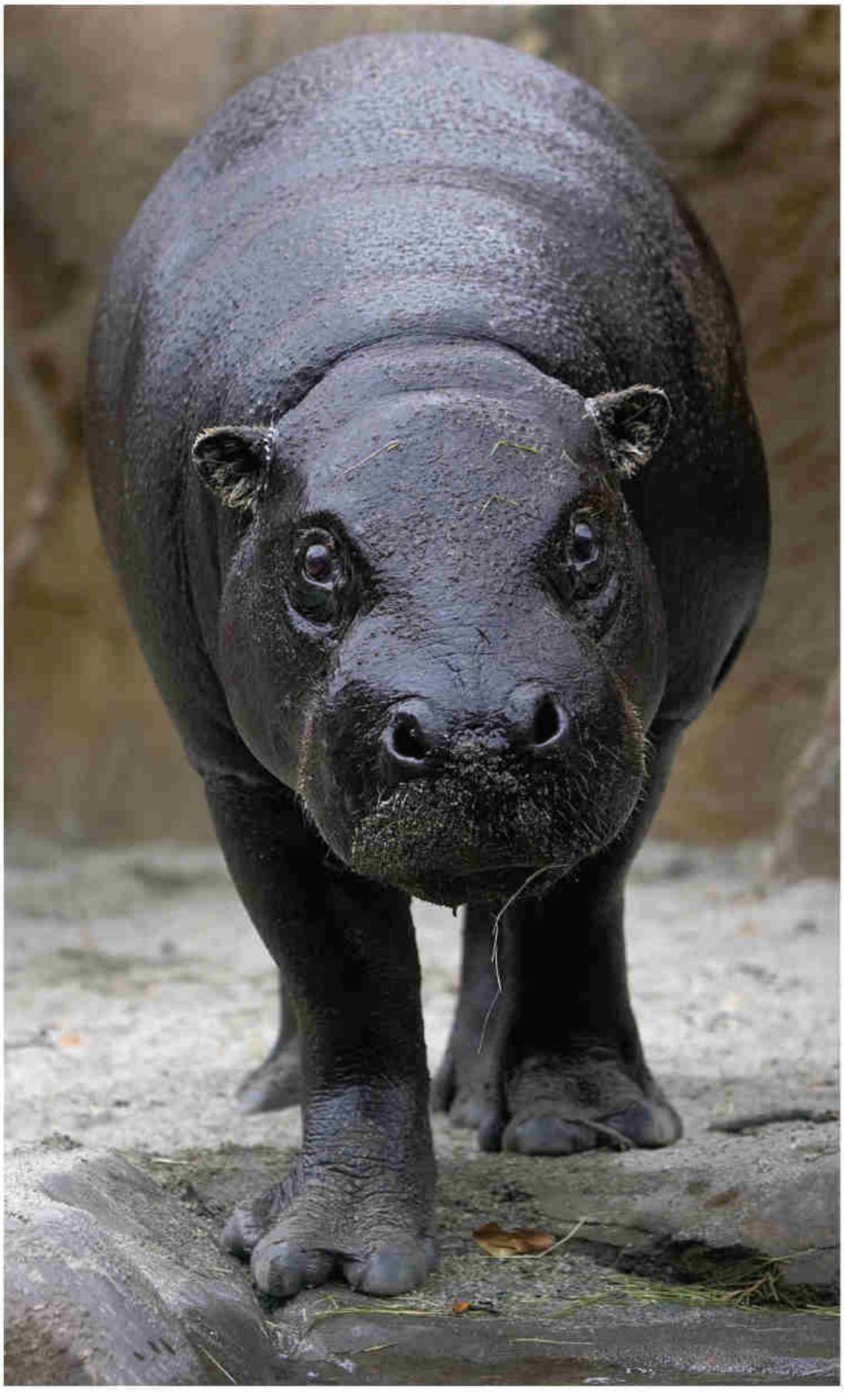
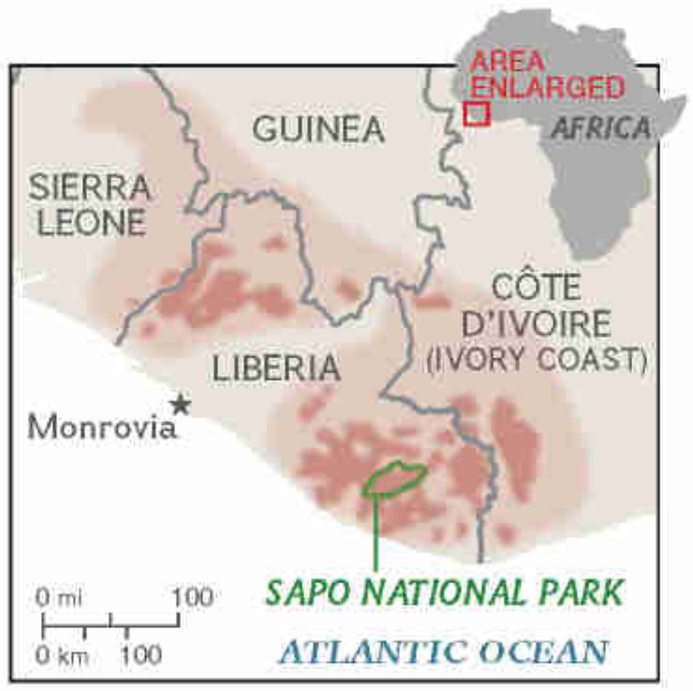
honda.com 1-800-33-Honda EX-L V-6 6MT model shown.

STEALTH CAM A pygmy hippo returns to its daytime hideout by the river after foraging overnight in the forest.



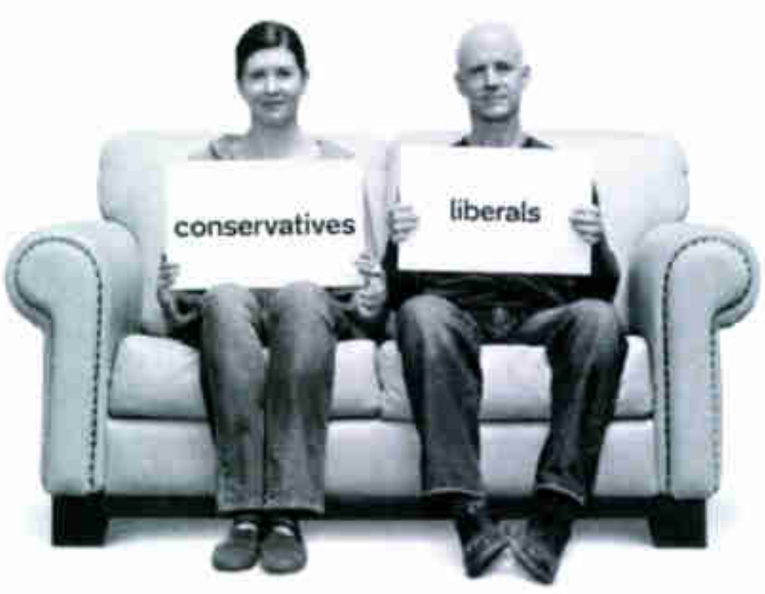
About 315 pygmy hippos live in captivity, this one in San Diego.

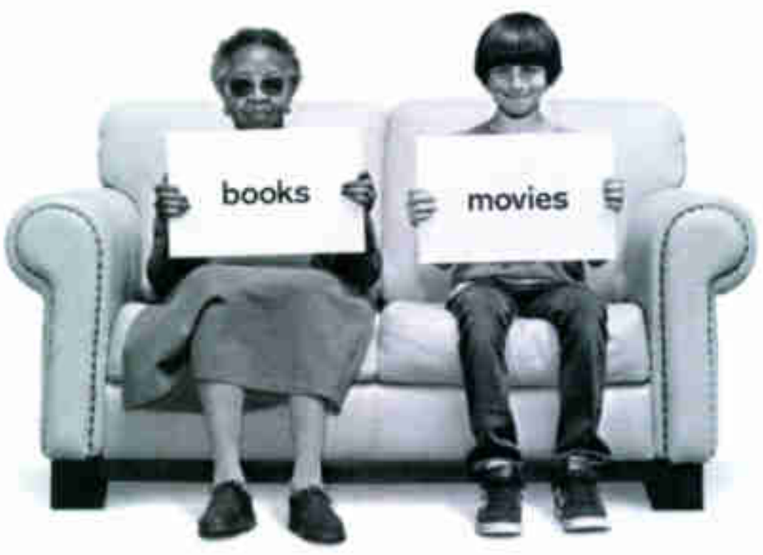


Hidden Hippos

The pygmy hippo is a solitary, elusive creature, pushing its way like a squat, 500-pound battering ram through the dense undergrowth of forests in Liberia and nearby countries. As its territory was lost to logging and farming, then overrun by civil wars starting in 1990, conservationists could only guess how many remained—certainly no more than 3,000. So when Ben Collen of the Zoological Society of London heard that the first camera trap his team set up in Sapo, Liberia's largest park, had captured a *Hexaprotodon liberiensis* on its way back from foraging, he was overjoyed—and relieved. "It tells us they're still here." Now he plans to set up camera traps in other likely habitat to locate and monitor the remaining pockets of pygmies. *—Karen E. Lange*

PHOTOS: ZOOLOGICAL SOCIETY OF LONDON (TOP); SAN DIEGO ZOO/MINDEN PICTURES
NGM MAPS. SOURCE: PHILLIP T. ROBINSON, UNIVERSITY OF TOLEDO





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Shopping by the Numbers

With 45,000 products in an average supermarket, confusion lurks in every aisle. How do you pick, say, the most nutritious fruits or snacks or canned soup? This month, thousands of stores will post numbers by many items as a cheat sheet. Developed by Yale University's Griffin Prevention Research Center, the Overall Nutritional Quality Index scores foods from 1 to 100, based on nutrients, vitamins, sugar, and salt as well as impact on blood pressure and other health concerns. More stores plan to adopt the rankings in 2009. *—A. R. Williams*

FOOD CHAIN
Here's a sampling of items rated. More scores are at *onqi.org*.

	BROCCOLI	**100**
	BLUEBERRIES	100
	ORANGE	100
	GREEN BEANS	100
	PINEAPPLE	99
	RADISH	99
	SUMMER SQUASH	98
	APPLE	96
	GREEN CABBAGE	96
	TOMATO	96
	CLEMENTINE	94
	WATERMELON	94
	MANGO	93
	NONFAT MILK	91
	FRESH FIGS	91
	GRAPES	91
	BANANA	91
	AVOCADO	**89**
	OATMEAL	88
	BLACKBERRIES	83
	SOCKEYE SALMON	82
	RAW ALMONDS	82
	RAW PECANS	82
	ARUGULA	82
	BROWN RICE	82
	SNAPPER	82
	MILK (1% FAT)	81
	SHRIMP	**75**
	COUSCOUS	72
	RAW PISTACHIOS	70
	UNBUTTERED, UNSALTED POPCORN	**69**
	CANNED TUNA IN OIL, DRAINED	67
	VEGETARIAN SPLIT-PEA SOUP MIX	63
	INSTANT OATMEAL	61
	CANNED PINEAPPLE PACKED IN JUICE	60
	WHITE RICE	57
	SODIUM-FREE CLUB SODA	56
	MILK (2% FAT)	55
	CANNED KIDNEY BEANS	53
	MILK (WHOLE)	52
	SCALLOPS	51
	PASTA	**50**
	CANNED PEAS	49
	PRUNES	45
44	**NY STRIP STEAK**	
43	VANILLA YOGURT	
39	ORANGE JUICE	
39	SKINLESS CHICKEN BREASTS	
37	CANNED PEACHES IN LIGHT SYRUP	
36	LOBSTER	
34	DRIED APPLES	
32	TOMATO JUICE	
32	CONDENSED SPLIT-PEA SOUP WITH HAM	
29	ENRICHED WHITE BREAD	
28	WHOLE CHICKEN WITH SKIN	
26	RAISINS	
25	HAMBURGER (75% LEAN)	
24	APPLE CHIPS	
24	GREEN OLIVES	
23	**BAGEL**	
23	CONDENSED TOMATO SOUP	
23	PEANUT BUTTER	
23	SHERBET	
22	REDUCED-FAT SOUR CREAM	
21	CONDENSED CREAM OF BROCCOLI SOUP	
21	**SALTED, DRY-ROASTED PEANUTS**	
20	INSTANT CHOCOLATE PUDDING	
18	**FRIED EGG**	
17	**SWISS CHEESE**	
15	DIET SODA	
13	CENTER-CUT BACON	
11	PRETZEL STICKS	
10	**DARK CHOCOLATE**	
9	WHITE BREAD	
7	SALAMI	
5	HOT DOG	
4	**CHEESE PUFFS**	
3	MILK CHOCOLATE	
2	APPLE PIE	
2	REG. CUT BACON	
2	SALTINE CRACKERS	
1	SODA	
1	**POPSICLE**	

PHOTOS: MARK THIESSEN, NG PHOTOGRAPHER

ALAIN HUBERT

EXPLORATION HAS A NEW PURPOSE

Arctic Ocean Traverse – North Greenland, 2007: Three hundred miles from the nearest land, the Arctic Ocean laps at the edge of the sea ice, only yards from Alain Hubert's feet. While previous explorers encountered ice many meters thick, Hubert finds only water where the Ocean should normally be frozen into a thick multi-year ice pack. Dogged by anomalous sea ice conditions, Hubert is repeatedly forced to find an alternative route across the now open water. Still 120 kilometers from his goal, each new discovery of fractured ice leads him to fear for the worst. June 14th, 2007: Alain Hubert and Dixie Dansercoer's 106-day crossing ends, but the journey is far from over. Hubert continues his quest to find the cause of this change in the ice.

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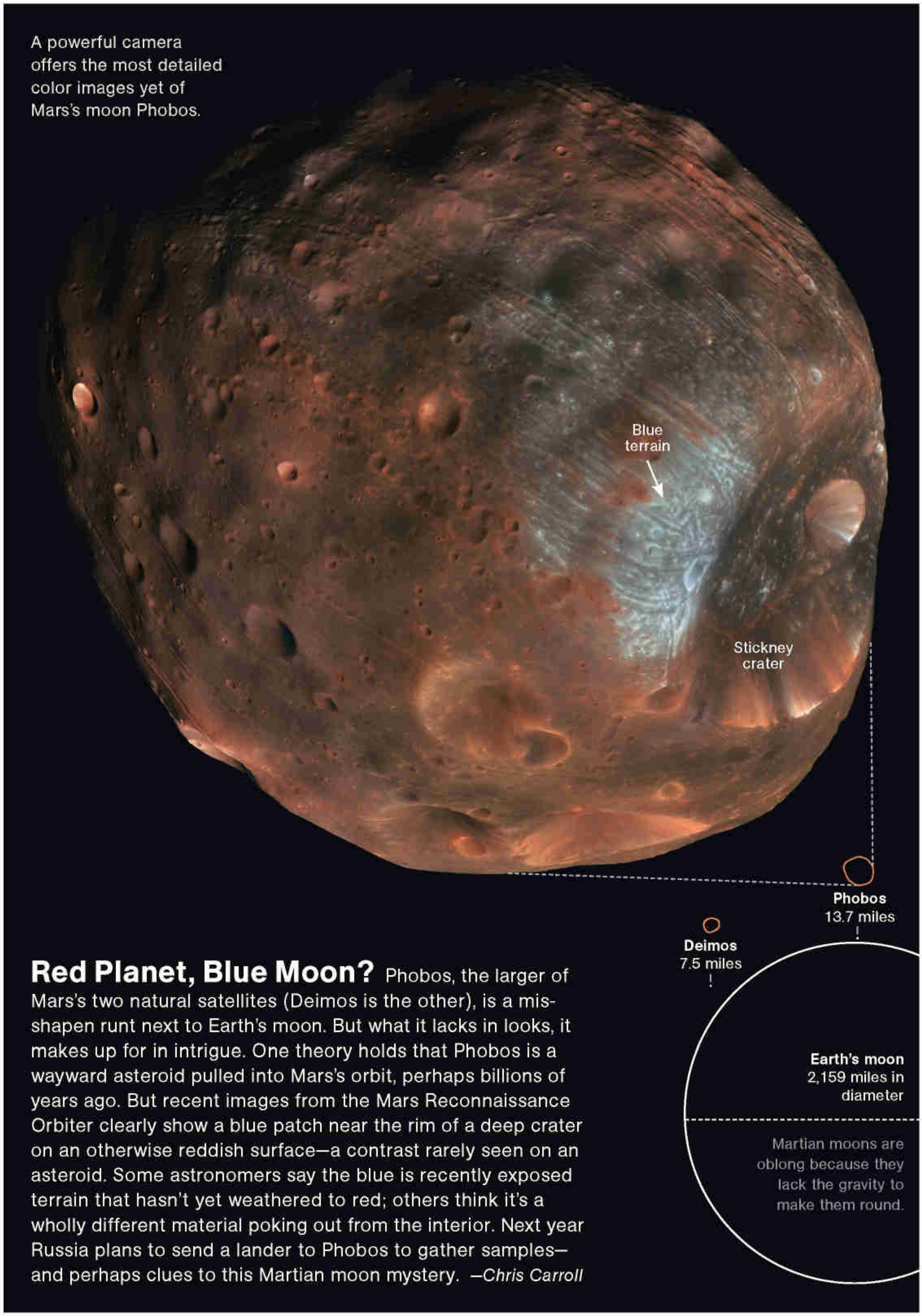
A powerful camera offers the most detailed color images yet of Mars's moon Phobos.



Red Planet, Blue Moon? Phobos, the larger of Mars's two natural satellites (Deimos is the other), is a misshapen runt next to Earth's moon. But what it lacks in looks, it makes up for in intrigue. One theory holds that Phobos is a wayward asteroid pulled into Mars's orbit, perhaps billions of years ago. But recent images from the Mars Reconnaissance Orbiter clearly show a blue patch near the rim of a deep crater on an otherwise reddish surface—a contrast rarely seen on an asteroid. Some astronomers say the blue is recently exposed terrain that hasn't yet weathered to red; others think it's a wholly different material poking out from the interior. Next year Russia plans to send a lander to Phobos to gather samples—and perhaps clues to this Martian moon mystery. *—Chris Carroll*

SATELLITE IMAGE: NASA/JPL/UNIVERSITY OF ARIZONA

American Red Cross

Measles remains a deadly killer that threatens children worldwide. The Measles Initiative, which has supported the vaccination of more than 500 million children in over 50 countries, is a partnership committed to reducing measles mortality.

Leading this effort are the American Red Cross, United Nations Foundation, Centers for Disease Control and Prevention, World Health Organization and UNICEF. To learn more, please visit www.measlesinitiative.org.

BD

Helping all people live healthy lives

Together in caring

A life-saving vaccine against measles has been available since the 1960's; yet measles remains a leading cause of vaccine-preventable deaths in the world. Immunization for every at-risk child is the objective of the Measles Initiative.

For the past 45 years, syringes made by BD have delivered more measles vaccines than any other company's. It is only natural that today, BD would partner with the American Red Cross in supporting this life-giving program.

BD SoloShot™ syringes are ideal to deliver the measles vaccine because they automatically disable after injection, which prevents reuse and the potential spread of infectious diseases. In addition, BD is supporting an intensive program to teach healthcare providers to inject the vaccine correctly.

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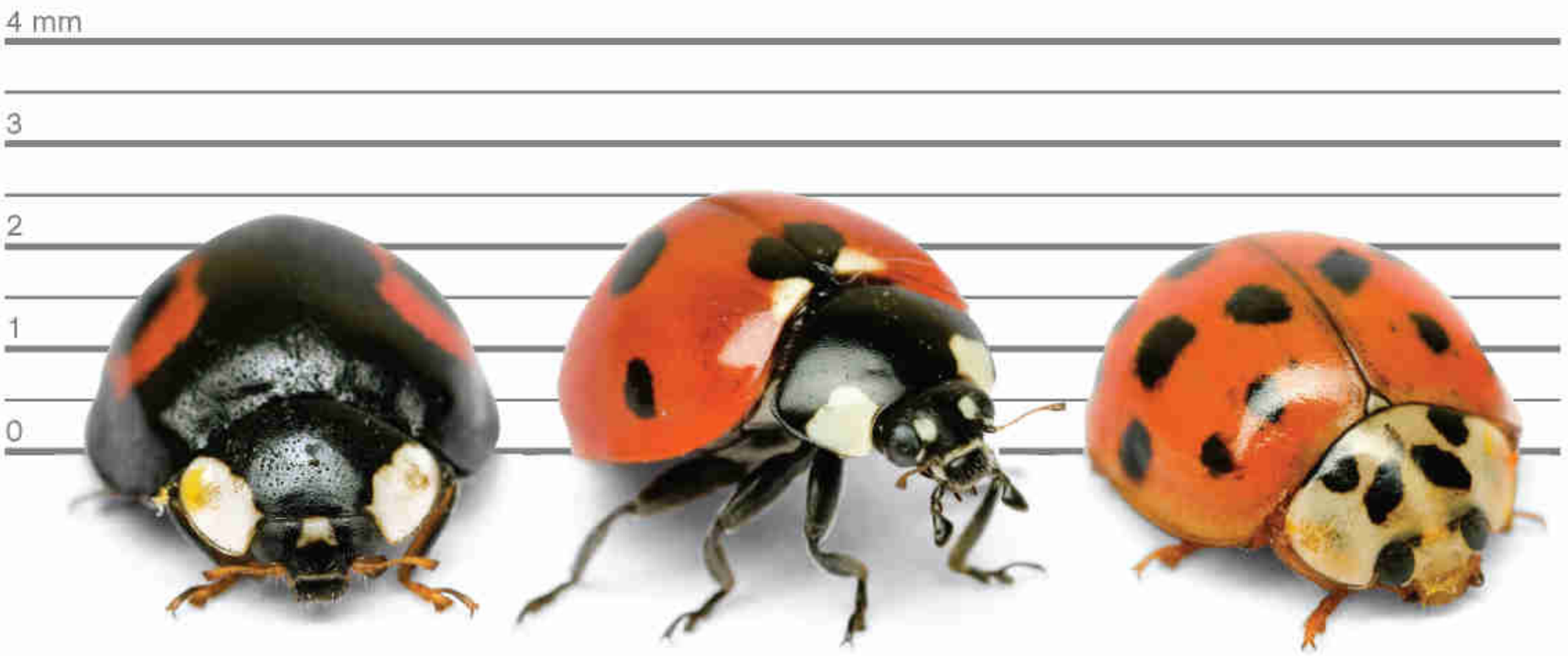
[1] *FORTUNE*, March 2008
[2] *Ethisphere® Magazine*, June 2008

Please visit www.bd.com

Photo ©Qualter-Bernal/US Fund for UNICEF

BUG SHOT

Harmonia axyridis is Britain's most wanted beetle.
It has varying guises—hence the name harlequin ladybug.
It reproduces faster than many indigenous species. And it's a cannibal.
Below, 1 and 3 are harlequins, flanking a native seven spot.



1 2 3

Tiny Troublemaker

Don't be fooled by its pretty pattern and comical name—the harlequin ladybug is no joke. This Asian beetle (Brits call them ladybirds) was first seen in England in 2004. Experts wager that it flew or blew in from mainland Europe, where it was introduced in the 1990s to control crop pests. Harlequins help by eating aphids but also eat a lot of other ladybugs, making it hard for natives to survive. And it's bad for one species to be responsible for aphid control with no backup. The Harlequin Ladybird Survey, an online database of sightings, is tracking the U.K. invasion. The goal is to learn more about how invasive species spread. Stopping the harlequin—say, with pheromone-laced traps—would be "terrifically expensive," says Peter Brown of the Centre for Ecology and Hydrology, who is coordinating the survey. The hope? "That a population crash occurs as a result of natural enemies or disease." Sounds like a job for lady luck. *—Catherine L. Barker*

PHOTOS: REDMOND DURRELL, ALAMY

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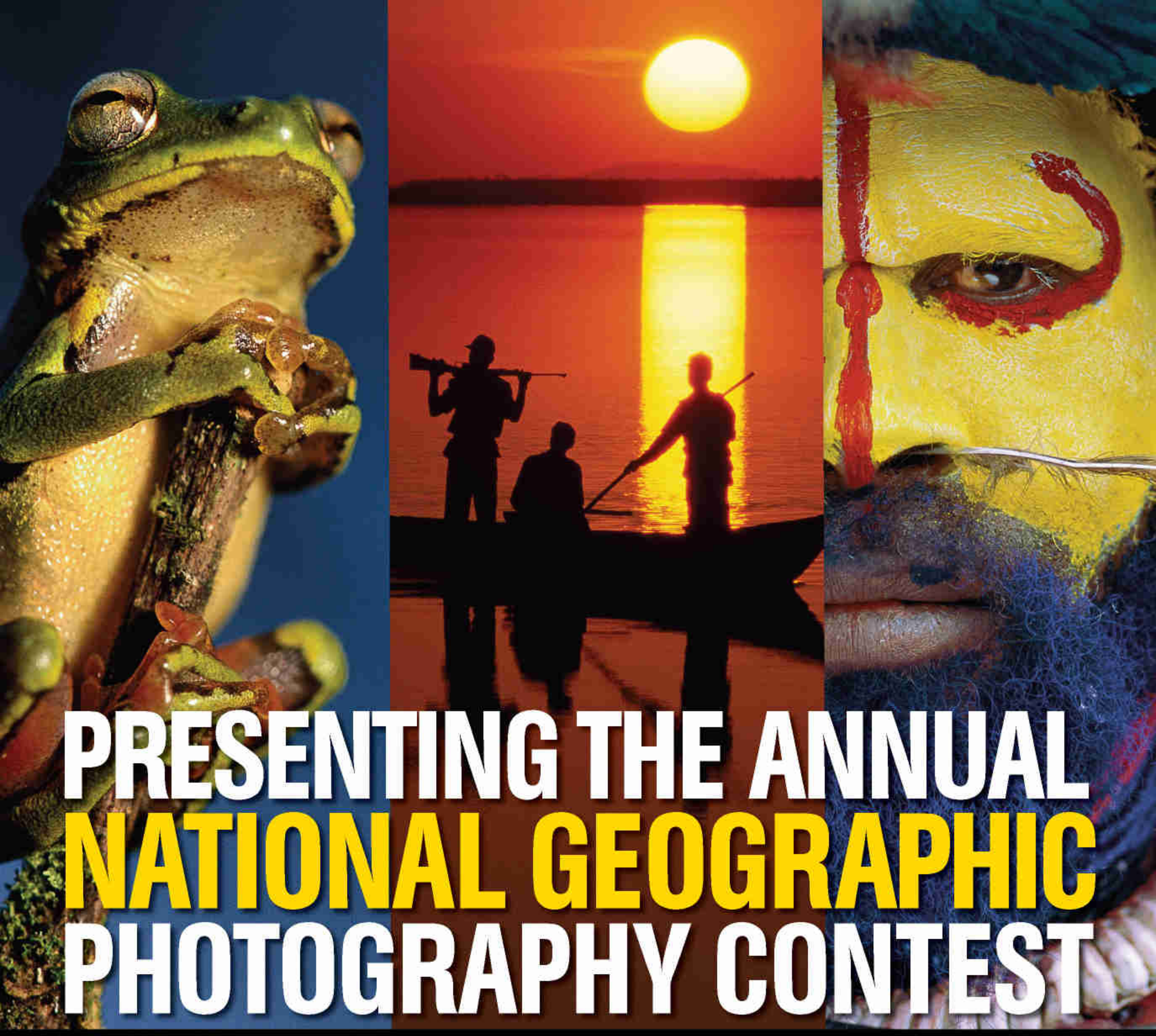

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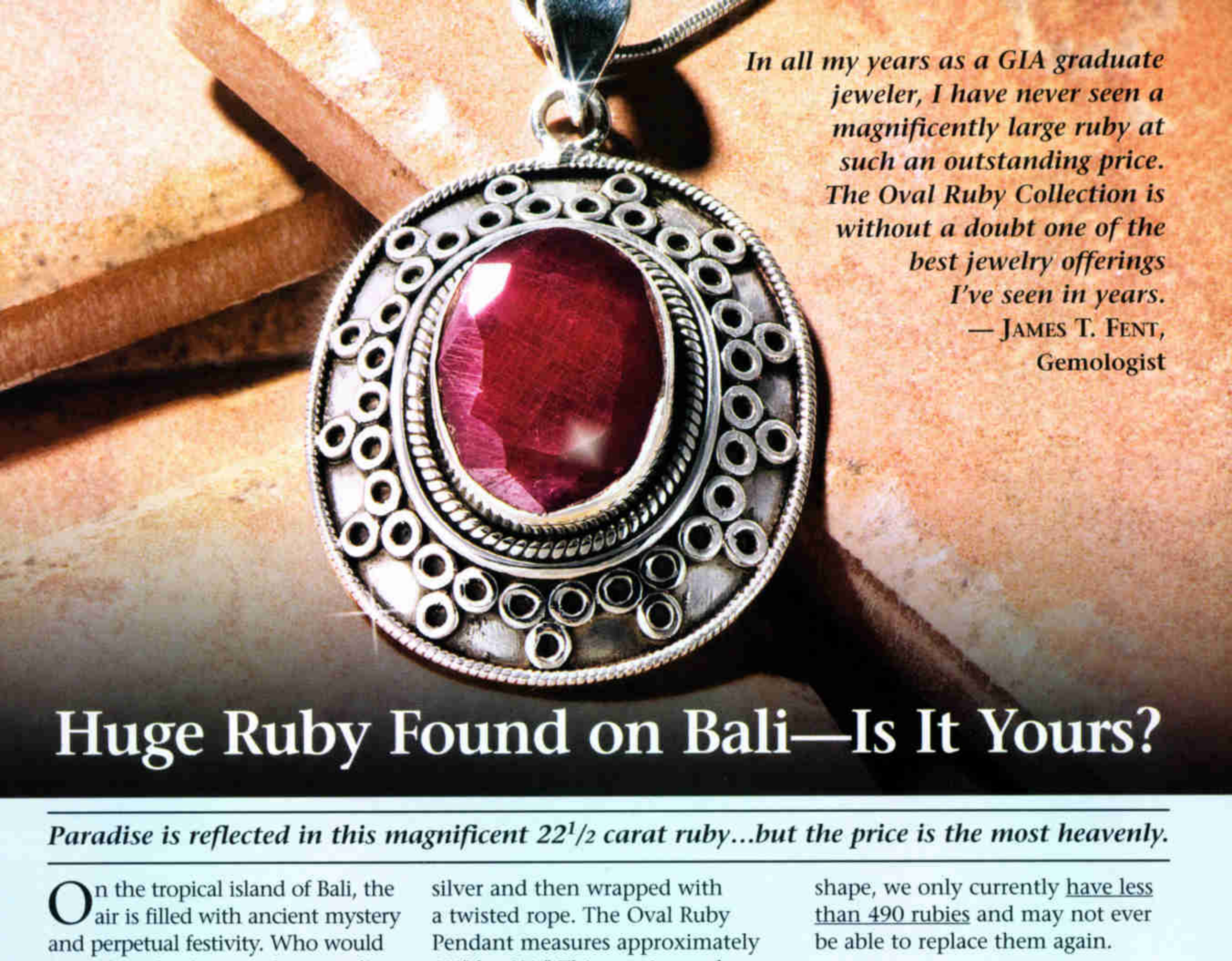

In all my years as a GIA graduate jeweler, I have never seen a magnificently large ruby at such an outstanding price. The Oval Ruby Collection is without a doubt one of the best jewelry offerings I've seen in years.
— James T. Fent,
Gemologist

Huge Ruby Found on Bali—Is It Yours?

Paradise is reflected in this magnificent 22½ carat ruby...but the price is the most heavenly.

On the tropical island of Bali, the air is filled with ancient mystery and perpetual festivity. Who would have thought that our deep sea diving trip to this romantic paradise would lead us to a treasure of giant deep red rubies. This beautiful isle is so vivid and untouched it has become the spiritual inspiration for many an artist. Bali has gardens tripping down hillsides like giant steps, volcanoes soaring up through the clouds, long white sandy beaches, and friendly artisans who have a long history of masterful jewelry designs.

We stumbled upon a cache of giant natural rubies at a local artisan's workshop. He brought these exotic Burmese Rubies to Bali and now we have brought them home to you. Our necklace showcases a genuine **22½ carat** facet cut ruby set in a frame of .925 sterling silver in the Balinese style. *That's right—22½ carats!*

The ruby, raised above the hand-crafted Balinese silver detailing is surrounded by a bezel of sterling silver and then wrapped with a twisted rope. The Oval Ruby Pendant measures approximately 1¼" by 1½." This exotic pendant suspends from a 21" silver snake chain and secures with a spring ring clasp. Drape this pendant around your neck for a bold luxurious look. And, since rubies are rarer than diamonds, we hope your rings don't get jealous. Most likely, this will be the largest precious gemstone that you will ever own.

Compare the size of a 1 carat ruby to our 22 ½ carat Oval Ruby.

The real surprise is that you probably expect this stone to sell for 1,000.00s of dollars. But our Stauer adventurers will go to the ends of the earth to find smart luxuries for you at truly surprising prices. And of course, if you are not thrilled with this find, send it back for a full refund of the purchase price within 30 days. As you can understand, this is an extremely limited offer. With rare rubies of this outstanding size and shape, we only currently have less than 490 rubies and may not ever be able to replace them again.

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- 18" sterling silver chain with 2" extender (optional)
- Stone color enhanced. Individual color may vary.

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Eating Green

What does eating green mean? It's choosing organics when possible, emphasizing vegetables, fruits, and grains over meats, and striving to find locally produced foods that travel fewer miles from field to market to kitchen. These can help cut down a meal's carbon footprint, or "foodprint," according to Cornell University nutrition researcher Jennifer Wilkins. Shoppers who walk, bicycle, or take public transportation to nearby farmers markets will reduce it even further. Maintaining a small foodprint minimizes the amount of natural resources used, but it doesn't have to mean depriving the palate. Consumers, Wilkins says, can eat a seasonal selection that "celebrates what your local farmers grow, week by week." Such flavorful ingredients might be reward enough for saving the world—one meal at a time. *—Diane Cole*

A patchwork of community plots provides the freshest produce to gardeners in Boston, Massachusetts.

Learn more about green living at **thegreenguide.com.**

PHOTOS: LOUIS WALLACH, ALAMY (TOP); ALEX S. MACLEAN, LANDSLIDES

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Workers in Parma, Italy, test unripe Parmesan cheese. Sliced Parma ham (below) is another local specialty.

Italian Local Specialties

SARDINIA *Su succu* is handmade tagliatelle baked with two fresh local cheeses, saffron, and a meaty broth.

TUSCANY Thin-skinned yellow beans called *zolfinos* are often boiled, drizzled with olive oil, and served on toasted bread.

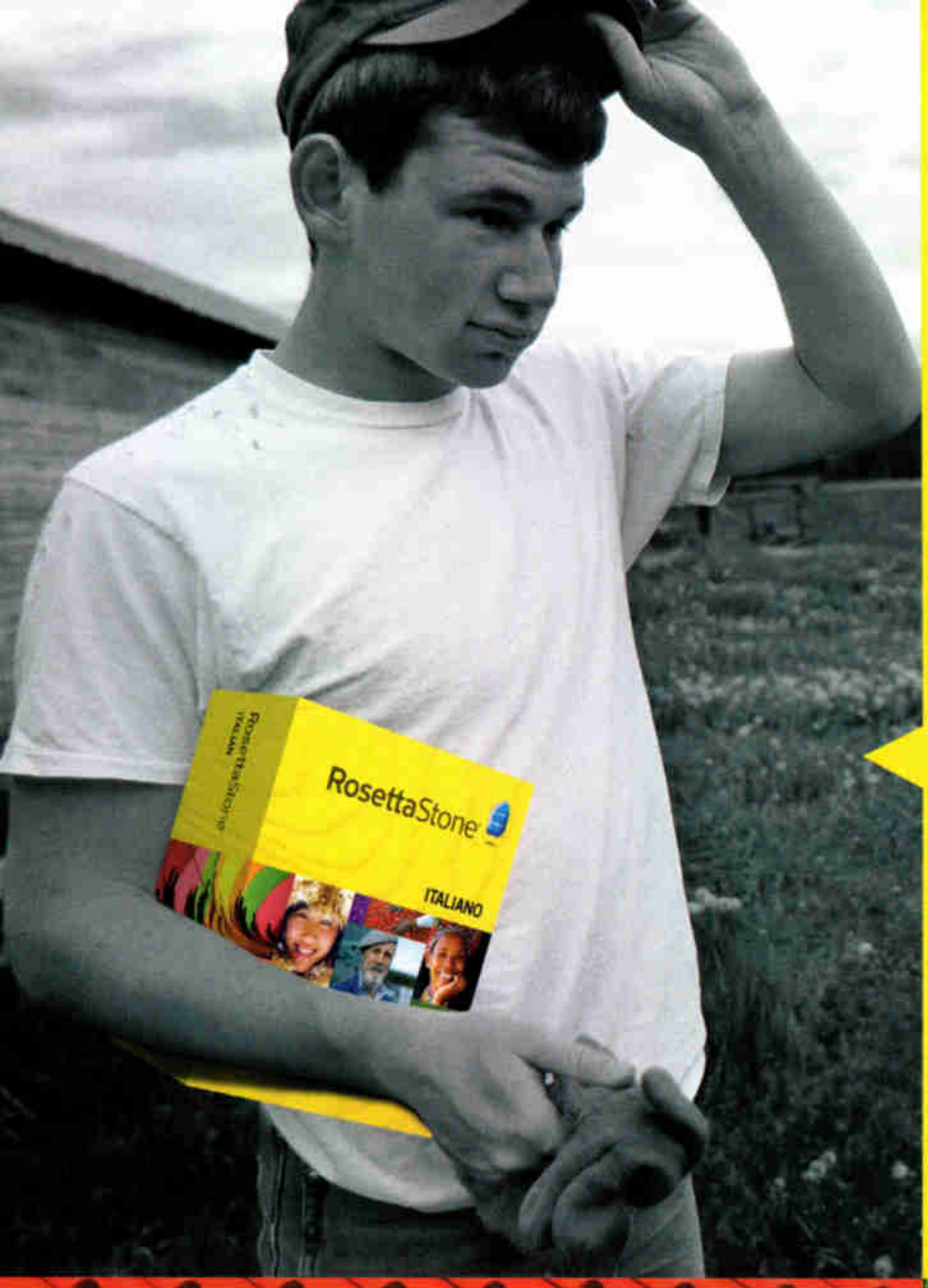
PIEDMONT The Asti region produces Robiola di Roccaverano, a mild white cheese.

Taking the Slow Road

Because it takes time to savor each of the courses that make up a traditional Italian meal, it seems fitting that the Slow Food movement—fast food's antithesis—was founded in Italy. Created by gastronome Carlo Petrini in the late 1980s, the now international organization does not advocate spending endless hours in the kitchen, however. It promotes a style of eating and cooking based on taste, freshness, and quality of local ingredients. Equally important to its mission is the preservation of individual regional specialties, the cultivation of local plants, and the rediscovery of artisanal food-production techniques.

Local wines provide the perfect accompaniment to slow food dishes; Italy is home to some 580 varieties of vines. "These grapevines, the best example of diversity in Italian agriculture, can be considered to be one of the most distinctive examples of Italian gastronomy," says Roberto Burdese, president of Slow Food Italy. "Every region in Italy produces wine, and every Italian regional cuisine has a strong connection to wine." Many regions are similarly renowned for their cheeses and locally pressed olive oils. Given the potential health benefits of a diet based on fresh produce, whole grains, and olive oil, the more slowly you eat such meals, the more of them you may have time to enjoy.

PHOTOS: GIANLUCA COLLA, NGM MAPS



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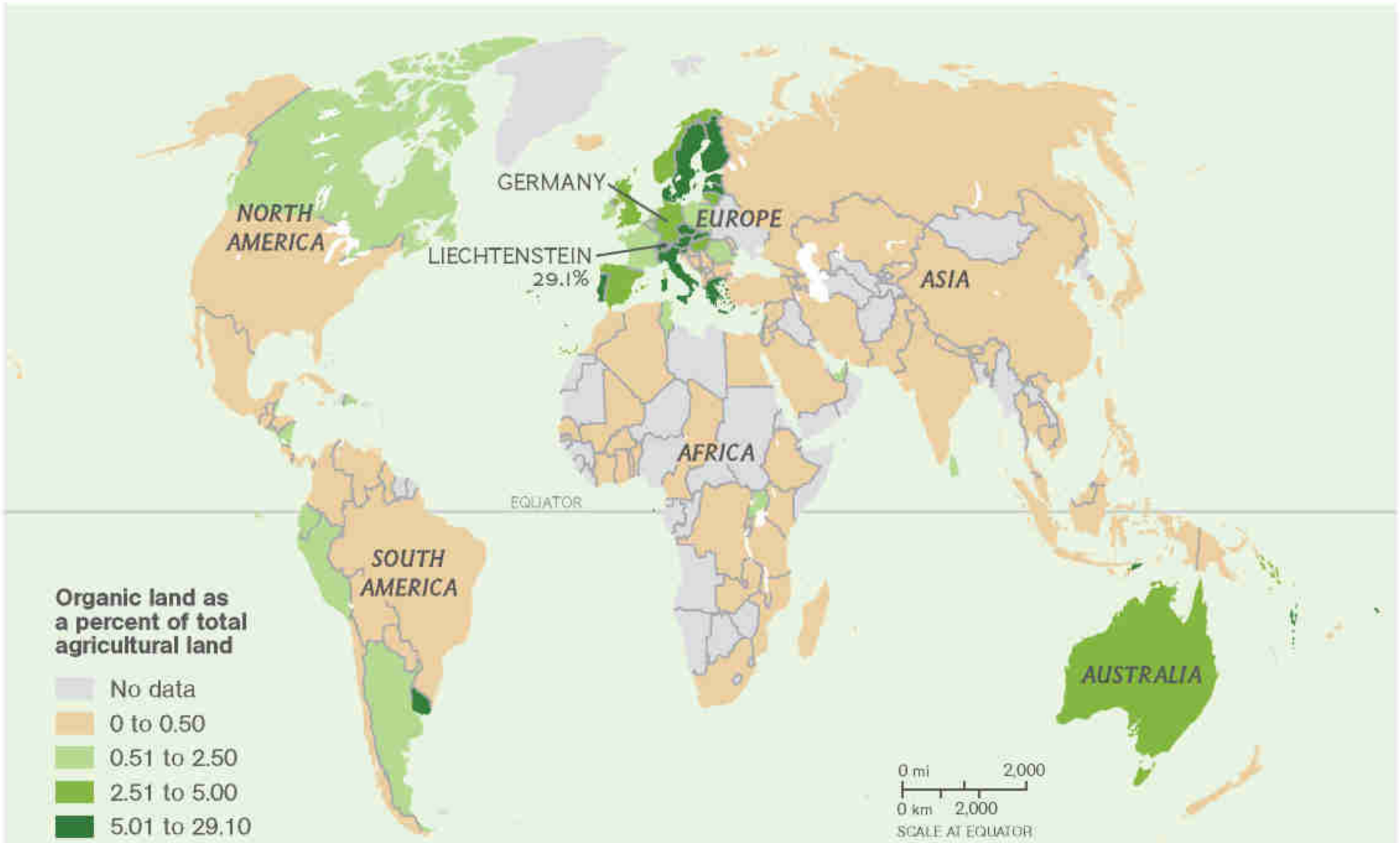

ORGANIC FARMING

More than 76.6 million acres of land around the world now carry organic certification, a boom fueled by a $40 billion international demand for organic foods. As a 2007 study from the University of Michigan challenges old assumptions that yields from organic farms can't compete with those from conventional agriculture, an ever greener map appears likely.

Munich Market

Munich's sprawling Viktualienmarkt offers every type of victual imaginable, its bustling food stalls catering to locals and tourists alike. Founded in 1807 as a farmers market, the Viktualienmarkt's organic produce, dairy products, and local game are much in demand here—and throughout the country. Germany is among the world's top consumers of organic goods; sales of organic foods have more than tripled in the past ten years. In fact, Germans may love organic food too much: The country faced shortages in 2007.

PHOTO: CARSTEN PETER, NGM MAPS
SOURCE: IFOAM, SÖL, FIBL, *THE WORLD OF ORGANIC AGRICULTURE, 2008*

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On the menu for Fife Diet followers: rhubarb from the Pillars of Hercules organic farm in Fife, Scotland.

The Fife Diet Food's a subject close to home for Mike Small. In November 2007 the Fife, Scotland, man convinced local people to dine for a year solely on foods produced in their 40-by- 30-mile area. Air-freighted goods—not from Scotland—are off-limits. Permitted on the Fife Diet are produce, eggs, and meat from nearby farms, as well as home-brewed beer. "It's liberating, discovering what your region can and can't produce," says Small. Even for those outside Fife, eating what's grown close by has benefits. Buying local food just three times a week "would make an enormous impact," says New York University food studies professor Marion Nestle, by increasing demand and supporting farmers.

Underground Ovens Steam rising from beneath the ground is a common sight in Bjarnarflag, a geothermally active stretch of land in northern Iceland. So are the rocks holding down the tops of assorted pots, pans, and buckets buried in the 212°F earth. What's cooking in these fueled-by-nature bakeries is *hverabraud* (left), a dark rye also known as geyser bread. Cooking time is about 24 hours, says Ólöf Hallgrímsdóttir, who bakes batches daily for her family farm, guesthouse, and café. She serves the bread with butter churned from milk produced by cows on her farm and with locally caught, home-smoked trout. Some traditional Icelandic foods—like preserved, fermented shark—are an acquired taste. A more universal palate pleaser is *skyr,* a thick yogurt often served with berries.

PHOTOS: LUCA FERRARI, PROSPEKT (TOP); RAGNAR TH SIGURDSSON, ARCTIC-IMAGES

ZAYED FUTURE ENERGY PRIZE

Einstein,

Faraday, Galileo, Ibn Sina, Newton,

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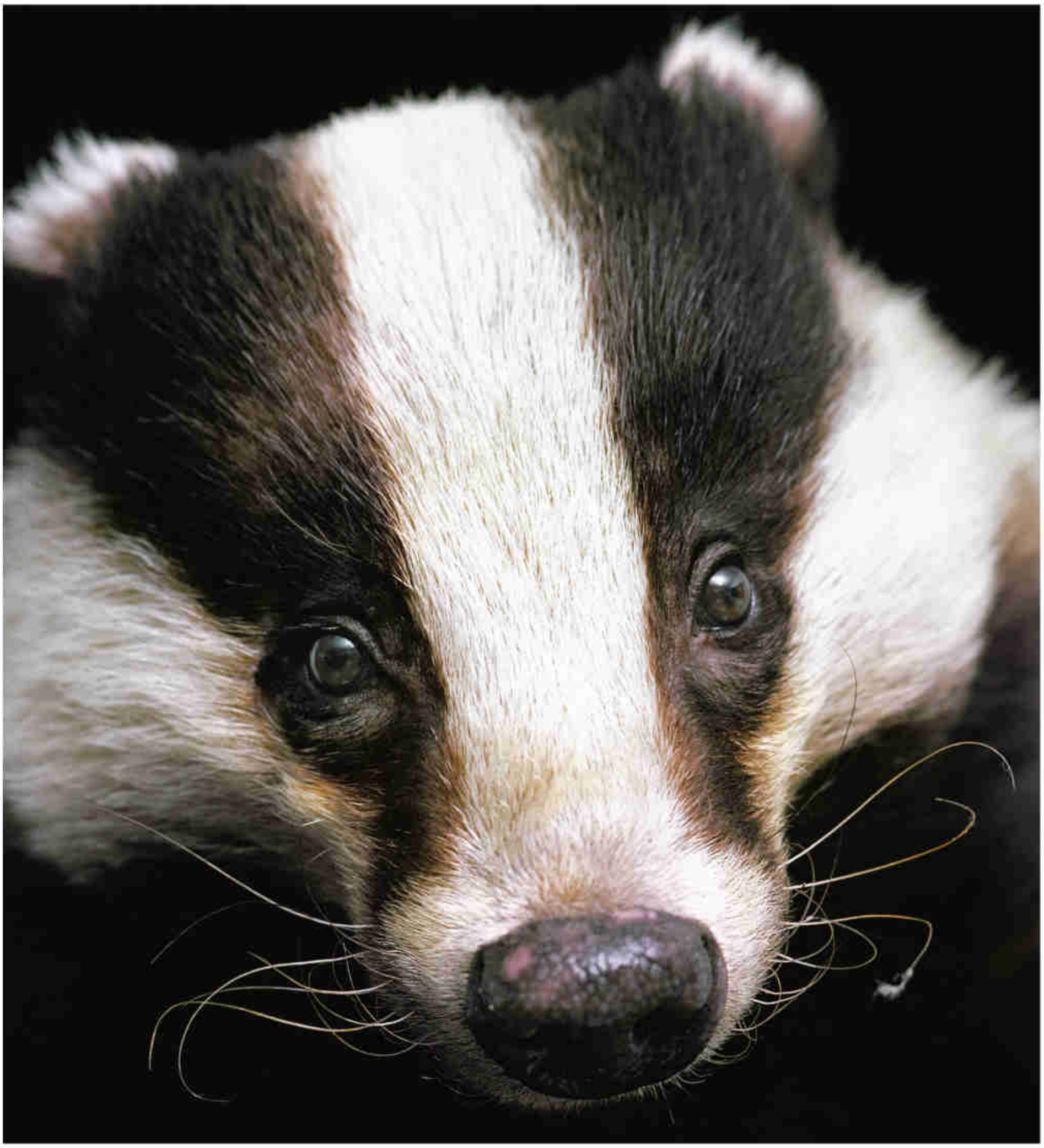


Britain's badger population benefits from the Protection of Badgers Act. But farmers aren't big fans.

Badgers' Bad Rap Mr. Badger of *The Wind in the Willows* "simply hates society." No wonder. Farmers blame Britain's 350,000 badgers for the ongoing problem of bovine tuberculosis and are calling for a cull. Badgers sneak into barns to steal feed, catch TB from cattle, and pass it on. But they cause only a third of cases, says John Bourne, head of a ten-year bovine-TB study. He urges stricter cattle testing to stop the trade of infected animals.

Badgers are no strangers to scapegoating. Farmers everywhere think livestock stumble into badger burrows. That's largely a myth. So is the enduring idea that badgers are vicious—a legacy of baiting for dogfights. They do prey on marmots and the like, and are unpredictable. But nasty? Hardly. "I've had my nose less than ten inches from a badger's," says biologist Roger Packham. "Not once have I been threatened." And Mr. Badger's soft spot for Mr. Toad isn't mere fiction: Hibernating toads do doze in badger dens. *—Marc Silver*

PHOTOS: TONY EVANS, MINDEN PICTURES (TOP); ROBERT CANIS, FLPA

TECHNOLOGY

Lightweight carbon-composite structure

Four motor gondolas (two shown)

Battery in each gondola

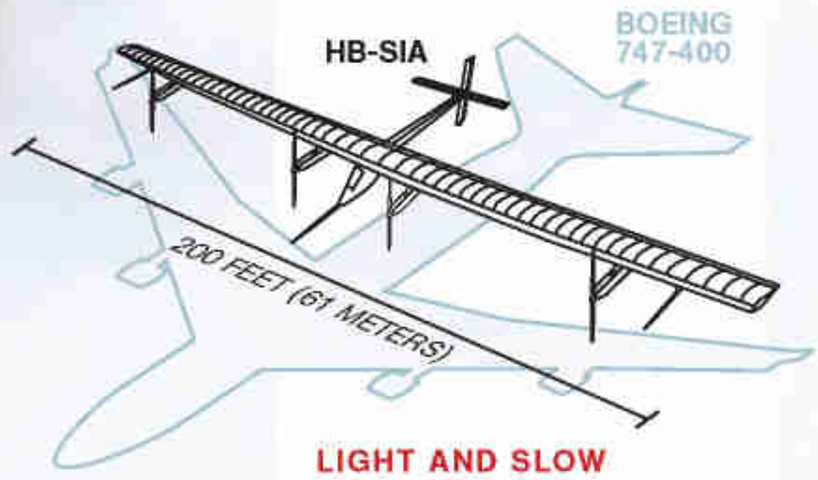
FLY ON PHOTONS

1 Sunlight hits 12,000 photovoltaic cells, averaging 6,000 watts, enough to light a big Christmas tree.

2 Lithium batteries, a quarter of the plane's weight, store energy for night flight.

3 A computer optimizes power use and gives flight data to the pilot and ground team.

4 The pilot maximizes efficiency by deciding when to climb and when to glide.



LIGHT AND SLOW

Weight 3,400 lbs

Maximum altitude 28,000 ft

Maximum speed 43 mph

Engine power 30 hp

Light Flight "The next time I fly around the world," thought Bertrand Piccard, "I don't want to have my eyes busy on the fuel gauge." That was in 1999, when the Swiss adventurer spent 19 days aloft in a hot-air balloon with 32 tanks of propane. He's getting half his wish: His next project, Solar Impulse, has gauges, but no fuel. Using only the sun's rays, the HB-SIA prototype (above) will take flight next spring. (A round-the-world trip with another plane is set for 2011.) Piccard's unique plane requires precise flying and top-notch meteorologists. So, will commercial airliners ever be solar powered? Nobody knows. But unmanned solar fliers—cheap to launch, easy to fix—could one day replace some satellites. Meantime, Piccard hopes to inspire people on the ground to reach for new heights in alternative energy. *—Helen Fields*

*SOME STOPS STILL TO BE DETERMINED

ART: HIRAM HENRIQUEZ, NG STAFF. SOURCE: SOLAR IMPULSE. NGM MAPS

family ties

THE ELEPHANTS OF SAMBURU

Happy families are all alike, wrote Leo Tolstoy; every unhappy family is unhappy in its own way. But the great Russian novelist wasn't thinking of elephants, whose familial relations are complex, various, and fascinating, even amid the relatively happy circumstances of Kenya's Samburu National Reserve.

ADULT SUPERVISION Security and learning are crucial to elephant society. On the savannas of Samburu, infants in family groups get vigilant protection from females functioning almost as a council of mothers. Adolescents tussle amiably, developing social skills as well as confidence and strength.

SOCIAL NICETIES Their whistles wet from an afternoon drink, two young males grapple. Such physical contact can be subtly nuanced along a spectrum from bonding to roughhousing to real combat. Harmless scuffles among juveniles help inform later, more serious interactions by which adults settle their disputes.

SAFE HAVEN Along the southern edge of the Samburu reserve, the Ewaso Ngiro River offers cooling refreshment, especially during the dry season, when the upland puddles disappear. Amid a shady forest of legs and bodies, close beside its mother, a calf finds shelter from the glaring world. Careful: Don't step on the baby.

An African Love Story

BY DAVID QUAMMEN
NATIONAL GEOGRAPHIC CONTRIBUTING WRITER

PHOTOGRAPHS BY MICHAEL NICHOLS
NATIONAL GEOGRAPHIC PHOTOGRAPHER

THE BIOLOGIST IAIN DOUGLAS-HAMILTON is walking up on an elephant, a sizable young female, nubile and shy. Her name, as she's known to him and his colleagues, is Anne. She stands half-concealed within a cluster of trees on the knob of a hill in remote northern Kenya, browsing tranquilly with several members of her family. Around her neck hangs a stout leather collar along which, at the crest of her shoulders, like a tiny porkpie hat, sits an electronic transmitter. That transmitter has allowed Douglas-Hamilton, flying in by Cessna, proceeding here on foot through the tall grass and acacia scrub, to find her. Crouching now, he approaches upwind to within 30 yards. Anne gobbles some more leaves. She's oblivious to him, or maybe just not interested.

Elephants can be dangerous animals. They are excitable, complex, and sometimes violently defensive. Douglas-Hamilton is a world-renowned expert who has studied them for 40 years. Don't try this at home.

He wants a clear look at the collar. He has heard reports that it may be too tight—that she has grown into it since having been tranquilizer-darted, fitted, and thus recruited as a source of research data. Ordinarily, Douglas-Hamilton does his elephant-watching more cautiously, from the safe containment of a Land Cruiser, but no vehicle can drive this terrain, and Anne's comfort and health are at issue. The collar should hang loose, with a dangling counterweight below. He wants to be sure that Anne's isn't snugged up to her throat like a noose. But at present, amid the thicket, she's showing him only her imperious elephantine butt. So he creeps closer.

Three other men lag back. One is David Daballen, a bright young Samburu protégé of Douglas-Hamilton's, who often accompanies the boss on missions like this. The second man is a local guide holding a Winchester .308 rifle. The third is me. As we watch Douglas-Hamilton edging forward, we notice another female elephant, a big one, probably the group's matriarch, sidling around craftily on his right flank. We duck low to escape the matriarch's view. We freeze. As this female comes on, suspicious and challenging, Douglas-Hamilton seems unconcerned with her, but Daballen begins to look nervous. He is calculating (he'll tell me later) how fast an elephant might be able to charge across such a rocky, rubble-strewn slope.

Then the big female commits herself to a sequence of gestures suggesting nonchalance, if not outright contempt: She pisses torrentially, she defecates galumphingly, and she turns away.

Anne herself swings daintily out of the brush. She steps toward Douglas-Hamilton. The gap between them is 50 feet. For a few seconds the young female graces him with a frontal view of her large forehead, her flappy ears, her pretty tusks, as though posing for beauty shots in the glow of a flash. She gives him a profile. He raises his camera and clicks off several frames. Then she too turns and ambles away. Through his lens, in those seconds, he has seen that the collar hangs just as it should. The alarm was a false one. Anne is in no danger—or anyway, no danger of chafing or choking.

Iain Douglas-Hamilton: The Scottish boy's dreams of Africa, wild animals, and flying came true as a lifetime of science, conservation activism, and adventurous aviation. Lucky the man who so loves his job.

As we withdraw, circling back toward our vehicle, I think: So that's how it's done. Show a little caution, a little respect, get the information you need, back off. And everybody is happy. After four decades Douglas-Hamilton knows this species about as well as anyone in Africa. He has a keen sense, well earned by field study and sharpened by love, of the individuality of the animals—their volatile moods, their subtle signals, their range of personalities and impulses. Nothing about his interaction with Anne has prepared me for the moment, some weeks later, when I'll watch him charged, caught, thrown, and nearly tusked through the gut by an elephant.

SOON WE'RE ALOFT again in Douglas-Hamilton's Cessna, flying low over the contours of the landscape. It's his preferred style, flying low; why go up a thousand feet when you can caress the topography? So we rise and descend gently over the rocky slopes, the ridges, the dry acacia plains, the sand rivers, returning northeast toward a place called Samburu National Reserve. Just beyond the reserve sits a gravel airstrip and, not far from that, his field camp. We'll be home before dark.

Samburu National Reserve is one of the little-known jewels of northern Kenya, taking its name from the proud tribe of warriors and pastoralists in which David Daballen, among others, has his roots. The reserve is a relatively small area, just 65 square miles of semiarid savanna, rough highlands, dry washes (known locally as *luggas*), and riparian forests of acacia and doom palm along the north bank of the Ewaso Ngiro River. Lacking paved roads, sparsely surrounded by Samburu herders, it teems with wildlife. There are lions, leopards, and cheetahs, of course, but also Grevy's zebras, reticulated giraffes, beisa oryx, gerenuks, Somali ostriches, kori bustards, and a high diversity of showy smaller birds such as wattled starlings, pin-tailed whydahs, and lilac-breasted rollers. But the dominant creatures are the elephants. They play a major role in shaping the ecosystem itself—stripping

bark from trees or uprooting them, keeping the savanna open. They intimidate even the lions. They come and go across the boundaries of the reserve, using it as a safe haven from human-related dangers in a much larger and more ambivalent landscape.

The larger landscape includes all of Samburu District (within which the reserve lies) and parts of three other districts, most notably Laikipia, a high-elevation patchwork of private ranches and sanctuaries, community conservation areas, wheat fields, fences, mountain slopes, stream valleys, roads, and shambas (small family farms) just to the south. In Laikipia, zones of wildlife habitat, crop production, cattle husbandry, and human habitation are juxtaposed like a spilled box of multicolored mosaic tiles. Samburu, by contrast, has fewer shambas and scarcely any fences. The Samburu people, who speak a dialect of the Maa language, have shown little inclination to surrender their traditional ways—tending goats and cattle, costuming themselves resplendently (especially the young men) in beads and feathers and red *shukas* (blankets), exchanging raids against their ancient enemies—in favor of modern, pusillanimous practices such as growing crops. Their traditionalism, along with a shortage of good soils and water and a growing awareness of the economic benefits of tourism, has so far spared Samburu District from the sort of intensive land conversion seen in parts of Laikipia. The combined Samburu-Laikipia ecosystem comprises roughly 11,000 square miles, and within it live about 5,400 elephants—the largest population of *Loxodonta africana* existing mainly outside protected areas anywhere in Kenya.

That population size and its current growth (at perhaps several percent a year) reflect the fact that Samburu-Laikipia is a productive, hospitable landscape for elephants, but two other adjectives are also applicable: edgy and complicated. Within the mosaic of mixed uses and shifting seasonal conditions, elephants face certain risks. So do people. Conflicts occur, resulting occasionally in a crop devastated by raiding elephants, or a cow killed, or an elephant shot, or a person trampled and tusked. And with Kenya's human population also growing by more than 2 percent annually, the potential for such conflicts can only increase. Decisions will be made about what should be protected (elephant travel corridors? cornfields? the right of people to continue establishing new farms?) and what must be sacrificed. Douglas-Hamilton's goal is to supply the makers of those decisions with scientific information more detailed and more timely, and therefore more useful, than any hitherto available. It's not precisely the same research agenda with which he began his career, but it's in the same spirit. It's where the contours of the landscape have led him.

"IF YOU HAD ASKED ME, when I was ten years old, what I wanted to do," Douglas-Hamilton says, "I'd have said: I want to have an airplane; I want to fly around Africa and save the animals."

Aviation was part of his lineage. His father, Lord David Douglas-Hamilton, had commanded a Spitfire squadron in the Battle of Malta and then died on a reconnaissance mission later in World War II; his three uncles had also been distinguished Royal Air Force (RAF) fliers. One of those uncles had earlier become the first man to pilot an open-cockpit biplane (he was dressed warmly) over the summit of Mount Everest, just for the sheer glorious hell of doing it. After the war Iain's mother was remarried, to a kindly man who read Iain stories about Africa and who took the family to live in Cape Town, then died abruptly himself. At age 13, Iain found himself back in Britain at a Scottish boarding school, nurturing dreams of a getaway. As an undergraduate at Oxford, he would have joined the RAF Volunteer Reserve, following the path of his father and uncles, but poor vision disqualified him. Zoology, fortunately, didn't require 20/20 eyesight.

"Science for me was a passport to the bush," he says, "not the other way around. I became a

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David Quammen's book Natural Acts *is available as an expanded edition. His current book project is an outgrowth of his October 2007 story, "Deadly Contact."*

He had a favorite named Boadicea, a great matriarch with long tusks that converged almost to a point, whose bluff could be called by standing firm.

scientist so I could live a life in Africa and be in the bush." Almost wistfully, he adds, "I would've liked to have been a game warden." But for a young Scotsman who spoke no Swahili, in the early 1960s, just before Kenyan independence, such a civil employment position was out. So he went to Tanzania as a research volunteer and then was offered a project in a small area called Lake Manyara National Park. With a bit of money from selling some inherited stock, he bought himself an old 150-horsepower Piper Pacer, nimble enough for tracking big animals, and learned by trial and error to land it on rocky airstrips.

There at Manyara, Douglas-Hamilton did the first serious study of elephant social structure and spatial behavior (where they go, how long they stay) using radio telemetry. It earned him a doctorate at Oxford. He also became the first student of elephants to focus closely on living individuals, not just trends within populations or the analysis of dead specimens. He used photographic records of visual patterns—unique ear notches and perforations, tusk shapes—for identification of animals in the field. He got to know the elephants one by one, noted their individuating traits, gave them names, watched their social interactions. He had a favorite named Boadicea, a great matriarch with long tusks that converged almost to a point, who made emphatic threat charges but whose bluff could be called by standing firm. There was another, a one-tusked female he called Virgo, very different from Boadicea, who acquired the habit of approaching his vehicle and reaching out toward Douglas-Hamilton with her trunk. After four years of slowly decreasing wariness, she would greet him with raised trunk and let him tickle her on its sensitive underside. He witnessed the infancy of a male named N'Dume, born to a female called Slender Tusks; he watched the calf learn to suckle, to use his trunk efficiently for grazing, and (on pain of chastisement) to avoid collapsing the water holes his mother had dug. Noticing the distinct traits of individuals and the generalized patterns within a population, Douglas-Hamilton began to wonder about motivations. What did elephants need? What did they want? How did their movements on the landscape reflect those cravings? What sort of choices did they make?

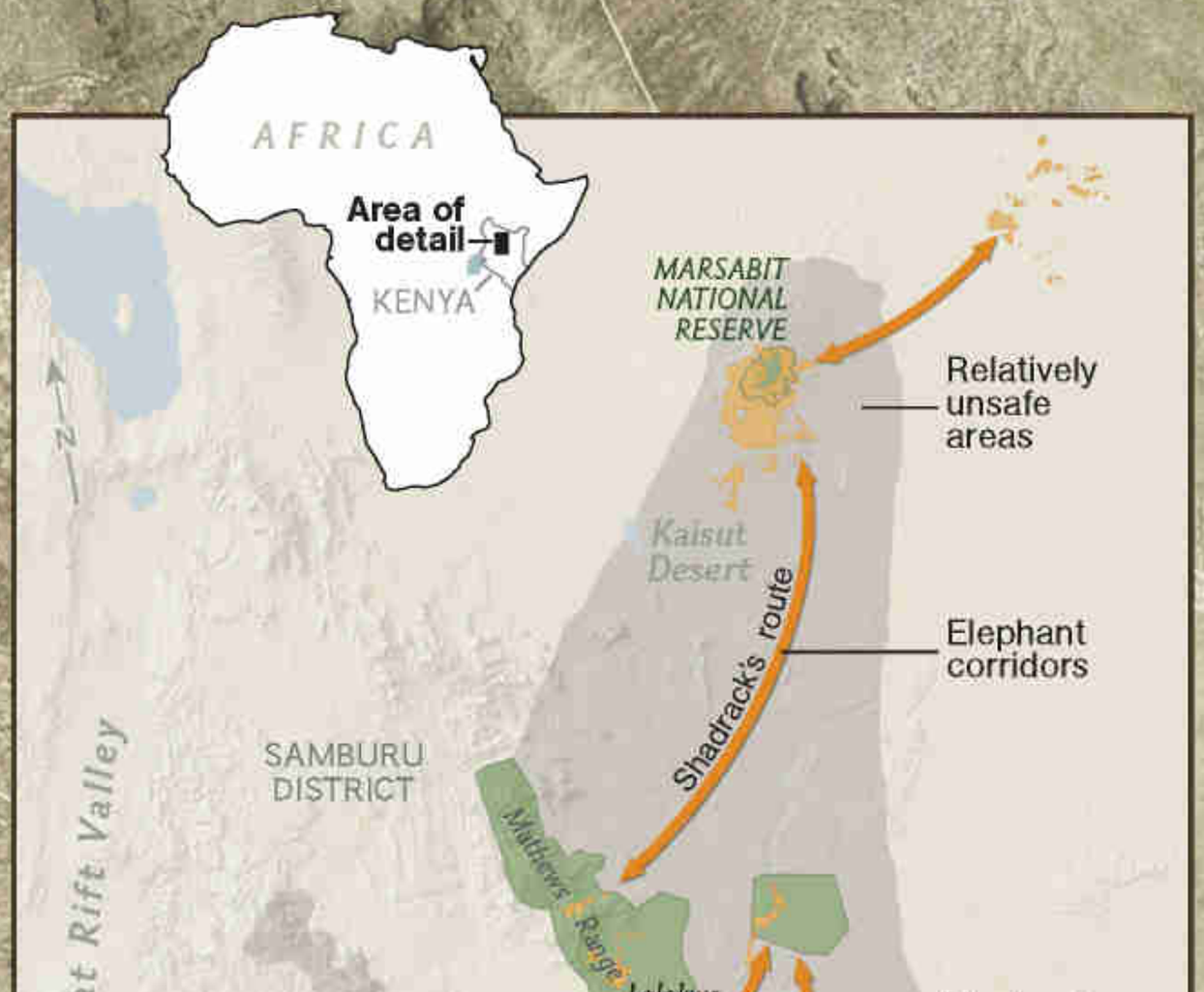
He married a Kenyan-born Italian beauty named Oria Rocco and took her back to the Tanzanian bush, where she shared his field life and his passion for elephants. Together, during the 1970s, they produced one best-selling book, *Among the Elephants*, and two luminous daughters. Photos from the time show Iain Douglas-Hamilton as a thin young man with wild, sun-bleached hair and nerdy glasses, wearing bush shorts and boots, sometimes a field vest but no shirt, deeply tanned, living a dashing life in the midst of friendly pachyderms: an amalgam of Tarzan, Clark Kent, and Doctor Doolittle.

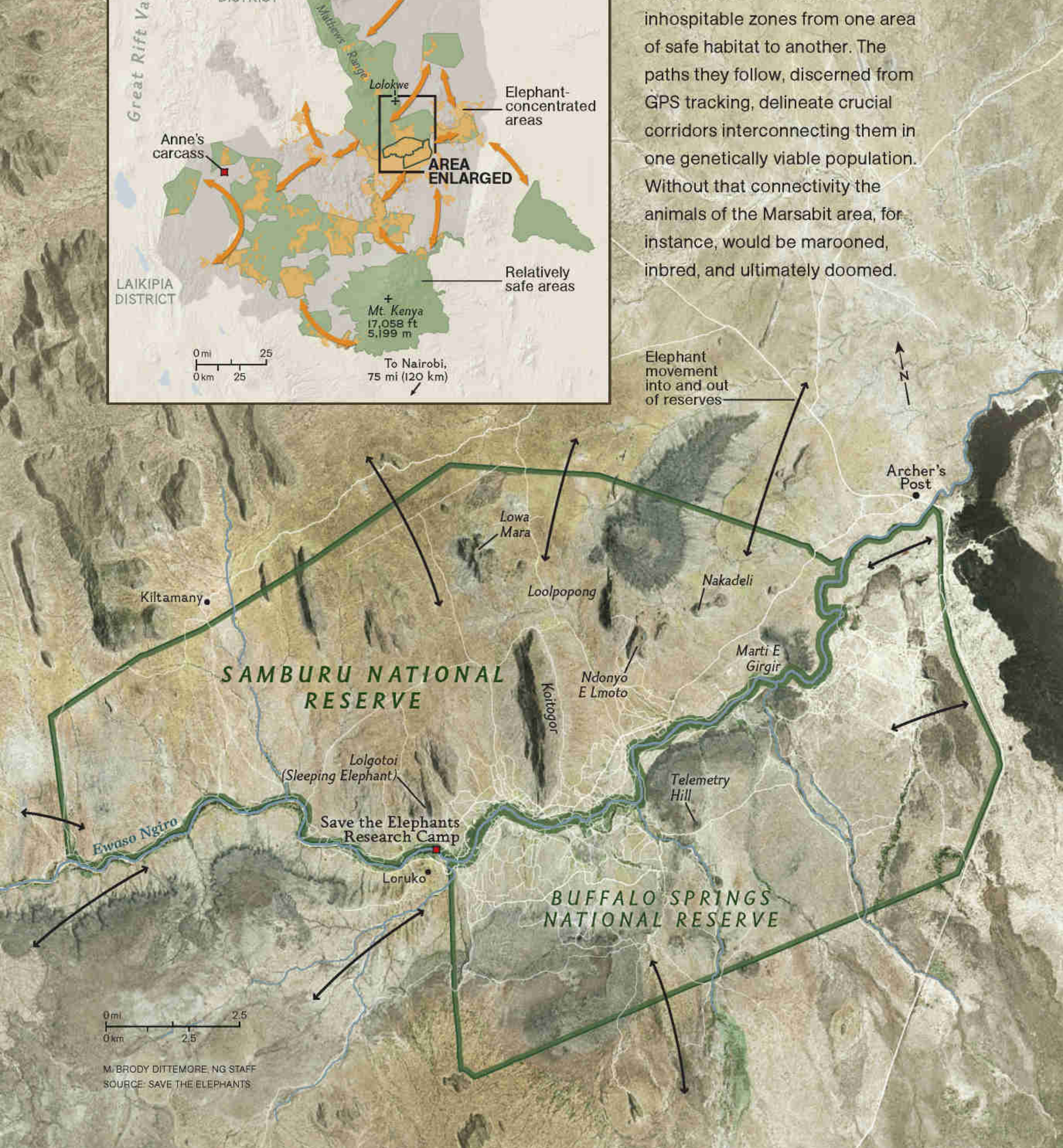
Then came the grim years of the late 1970s and '80s, when Douglas-Hamilton played a lead role in raising the alarm against an ugly development—the wholesale slaughter of African elephants. Killing elephants for their tusks wasn't new, of course. People have been doing

Society Grant This research is funded in part by your National Geographic Society membership.

Samburu and Beyond

In search of sustenance, sex, and security, the elephants of the Samburu-Laikipia ecosystem (inset map) travel frequently. Some journeys are local, others are long-distance "streaks" across inhospitable zones from one area of safe habitat to another. The paths they follow, discerned from GPS tracking, delineate crucial corridors interconnecting them in one genetically viable population. Without that connectivity the animals of the Marsabit area, for instance, would be marooned, inbred, and ultimately doomed.





that ever since the invention of the spear. But this modern phase, driven by a sudden sharp rise in the price of ivory and made gruesomely efficient by automatic weapons, was on a different scale. Between 1970 and 1977, according to one assessment, Kenya lost more than half its 120,000 elephants. Ivory exports from the continent—just the legal exports to major markets, not even considering small markets or smuggling—totaled about two million pounds a year. Based on that weight of tusks, Douglas-Hamilton calculated elephant losses throughout Africa at somewhere above 100,000 animals annually. He decided to do something.

With funding from several conservation NGOs, Douglas-Hamilton organized a hugely ambitious survey to gauge the status of elephant populations throughout the continent. He mailed out questionnaires to field biologists, game wardens, conservationists, and other well-informed people, asking for their counts or best estimates of local and regional populations, and he flew surveys himself. From the results, compiled in 1979, he figured that Africa then contained about 1.3 million elephants. It might seem like a sizable number, but there was a devil in the details; the trend lines pointed down. African elephants were dying at an unsustainable rate, Douglas-Hamilton concluded, putting the viability of their populations at risk.

Some experts in the field disagreed, arguing that elephant populations were doing just fine, or at least that Douglas-Hamilton's data were unreliable. Those disagreements eventually carried through the 1980s in a series of contentious meetings and bureaucratic battles that became known as the Ivory Wars. (Management of elephant populations is still a complex and contentious matter; see pages 64-69.) Meanwhile Douglas-Hamilton had set aside his behavioral studies and spent years investigating the status of beleaguered elephant populations in Zaire, South Africa, Gabon, and elsewhere, both by overflying to count animals and by amateur sleuthing on the ground. He went to the Central African Empire, nosed into the ivory trade there, and left quickly when the emperor, Jean-Bédel Bokassa, began to get curious about this visiting elephantologist. He flew into Uganda amid the turmoil after Idi Amin's fall, and saw bullet-riddled elephant carcasses littering the national parks.

"It was a dreadful time. I really spent a terrible 20 years doing that," he says now. His dangerous, gloomy work helped immeasurably to support the 1989 decision under the Convention on International Trade in Endangered Species (CITES) to outlaw the international sale of ivory. But on a personal level, it cost him—anxiety, years of his life, time away from his daughters, and time away from living elephants.

One of his colleagues in Kenya, Cynthia Moss, herself a highly respected elephant behavioralist, called my attention to that last category of cost. It's so important for an elephant researcher, she said, during a lunch in Nairobi, to be in the presence of known individual animals. Flying is useful, counting is useful, but those are no substitute for close, prolonged observation. Moss began her own career, back in 1968, as a research assistant to Douglas-Hamilton at Manyara, and she feels an old friend's sympathetic concern. "He didn't really come back to ground," she told me, "until he started up in Samburu."

HIS WORK in Samburu National Reserve has reflected a new role in Douglas-Hamilton's life: mentoring young scientists. He came, in 1997, along with a student he had placed there.

The student was George Wittemyer, an American Fulbright scholar who wanted to study elephant social relations. By that time, Douglas-Hamilton had established his own research-and-conservation organization, Save the Elephants (STE), based in Nairobi. He supplied Wittemyer with contacts, an aegis, and a couple of used tents, with which Wittemyer set up a simple field camp along the Ewaso Ngiro River, in the shade of some large acacia trees and near a conical hill. Just as Douglas-Hamilton had done three decades earlier at Manyara, Wittemyer began learning the local elephants, sorting out their family affiliations, and naming them.

From the Mathews Range, a vista of habitat stretches south toward flat-topped Lolokwe, sacred peak of the Samburu people. Elephant corridors across such terrain are vital to the viability of the population.

As in other elephant populations, each family was dominated and guided by a matriarch, an older female, mother or grandmother to most of the members. Wittemyer grouped the names in mnemonic familial clusters, a system that has been continued by later researchers at Samburu: the Spice Girls (including Rosemary, Basil, and Sage), the First Ladies (Eleanor, Martha, Lucy Kibaki, Jackie), the Biblical Towns (Babylon, Nazareth, Jerusalem), the Royals (Victoria, Cleopatra, Anastasia, Diana), and many others. Bulls tend to travel solitarily or in male affiliations, so the Samburu bulls are named more variously: Mungu, Gorbachev, Mountain Bull, Genghis Khan, Marley, Amadeus, etc. Roughly 900 individual elephants use the Samburu reserve in the course of a year, either as residents or as short-term visitors, and most of them are identified in STE records.

Gradually the two-tent camp became a permanent compound, ascetic but comfortable, comprising a dozen wall tents, a thatch-roofed kitchen, an office-and-dining-hall structure with a concrete floor and wireless Internet, plus outhouses and bucket showers. Douglas-Hamilton made this gracious outpost, now called Save the Elephants Camp, his base of operations.

The Save the Elephants project grew—into a doctorate for Wittemyer and a long-term monitoring program on social and spatial behavior for Save the Elephants. Other young men and women turned up, from within Kenya and far beyond, and with guidance from Douglas-Hamilton assumed a variety of responsibilities. Onesmas Kahindi, Maasai by descent but Samburu by affinity, took over the behavioral study, then found a role better suited to his gifts: gathering data on elephant mortality. Tall and charming, a natural schmoozer, Kahindi prowls the ecosystem like a traveling salesman, using records from the Kenya Wildlife Service (KWS) and his own network of local informants to guide him to every elephant carcass—both natural mortalities and elephanticides—that turns up. By documenting and tallying all those deaths, he maintains a crucial detection system

Daniel Lentipo (pictured) and researcher George Wittemyer hunkered inside this truck while a bull named Rommel thrashed it, expressing some displaced aggression after a humbling face-off with another male.

(part of an international program called MIKE, meaning Monitoring the Illegal Killing of Elephants) against resurgent poaching. Henrik Rasmussen, an ecologist from Denmark, complemented Wittemyer's work on female behavior with a study of reproductive tactics among the males. David Daballen, my companion for the outing to see Anne, was a high school graduate with a Ph.D. mind, recruited by Kahindi from a group of volunteer rangers; he worked as a field assistant until Rasmussen recognized the greater scope of his potential. Daballen is now camp manager as well as co-researcher on the long-term behavioral study. Daniel Lentipo, another local Samburu, with keen eyes and a wizard memory, became the other chief research assistant on that study. Douglas-Hamilton says: "I love the interface between these high-powered, overseas scientists and the Samburus of camp."

Of the 900 elephants that pass through Samburu National Reserve, Daballen and Lentipo can each recognize about 500 individuals on sight. Having watched births, matings, deaths, and group behavior over time, they also know the family histories. Daballen can tell you, for instance, that this magnificent female on the south bank of the river, so huge she looks like a bull, is Babylon, matriarch of the Biblical Towns; that she's nearly 50 years old; and that her breasts are full because that's her young calf standing nearby, along with her older daughter and her granddaughter. He can point out a youngish female limping piteously on three legs and explain that she's Babel, of the same family, probably crippled when she was mounted too young by a bull; but that the other Biblical Towns, taking their cue from old Babylon, move slowly so that Babel can stay with them. When Daballen looks at an elephant in this ecosystem, he sees an individual with a story embedded in a matrix of relationships and other stories.

Meanwhile Douglas-Hamilton, working with still other young collaborators, concentrates on the spatial *(Continued on page 60)*

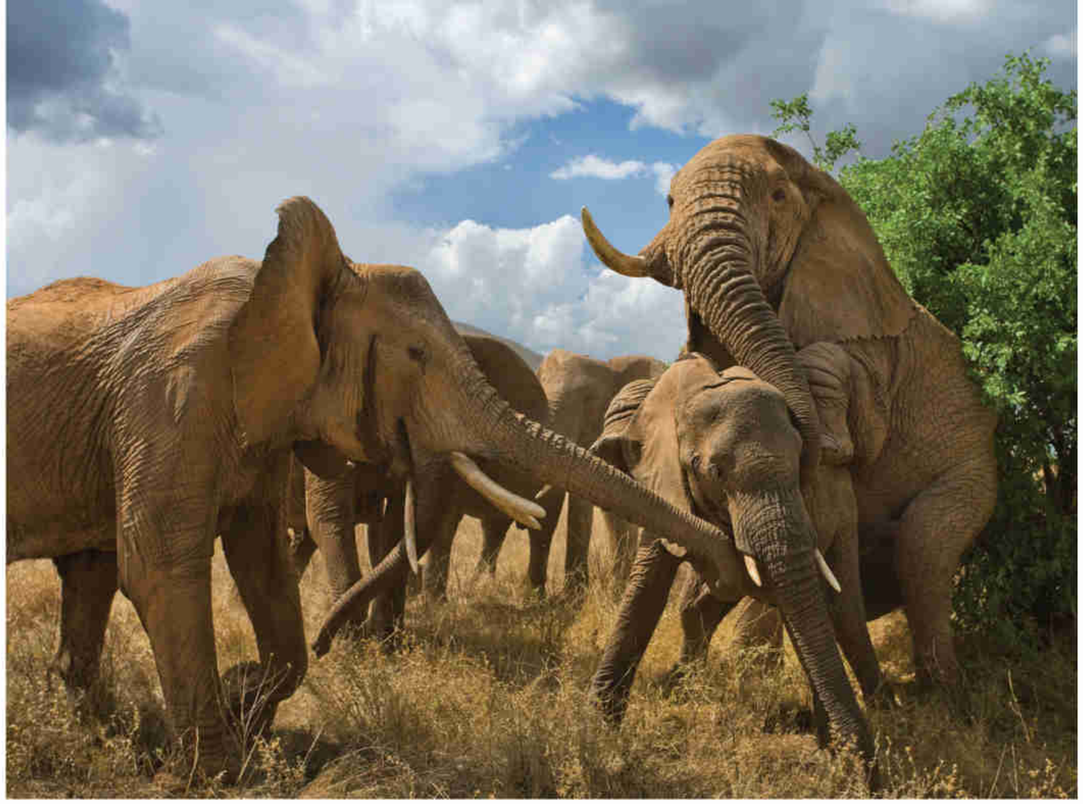
TAKE A LOAD OFF On a moonlit night an eight-year-old female dozes among her kin. Elephants can sleep standing up, but recumbency suggests deeper relaxation. This family, known as the American Indians and led by the matriarch, Navajo (at right, rear), is one of the calmest in the reserve, even by daylight.

LONELY YEARS A young male, when he reaches sexual maturity, is no longer welcome among his female relatives. He walks the landscape alone, at least until he can ally himself with other young bulls. Lessons learned in upbringing help to guide him. This 17-year-old, recently parted from the Royals, is adjusting slowly; he still sometimes revisits the family for tusk wrestling with his former playmates and younger siblings.

BULLS

MATRIARCHS

GENERATION UPON GENERATION Babylon is the quintessential matriarch, with a hole in her left ear and a half century of experience and knowledge in her head. Yet she's still a new mother as well as a grandmother, followed closely by her own tiny calf, and her daughter's, and a third. Another member of the Biblical Towns, Babel, badly lame, manages to survive and stay with the family because Babylon waits for her.



MATERNAL DISAPPROVAL Males will attempt to mate with any female in estrus, but a large bull can injure a small female when mounting her—breaking one of her legs, for instance, beneath his weight. After a three-day pursuit, Leopold tries with an eight-year-old from the First Ladies and is thwarted by her mother, Mary Todd Lincoln, and other females. Later, Mary Todd sanctioned her daughter's mating with a younger, smaller bull.

SHOWING RESPECT Boone, a formidable bull who spends most of his time east of the Samburu reserve, visits the Poetics and is met with embraces by Maya, the matriarch, and her eldest daughter. This is not, or not directly, about sex; neither female is in estrus. They seem to be merely expressing appreciation for an estimable individual, a fine male, who probably contributed genes to their lineage and may again.

LEISURE TIME Two of the Royals get afternoon shade, and a bit of scratching, beneath an acacia near the river. Their family is one of the more dominant, giving them first claim on good habitat. Dominant families tend to spend more time within the reserve and along the river and occupy smaller home ranges. Less movement through insecure areas means less exposure to risks such as falling afoul of farmers and herders.

ADOPTIVE MOTHER Saturn, an elderly mother herself, cares for two calves orphaned by the deaths of their mothers, who were her adult daughters. The extended family structure helps groups cope with such losses. At sunset along a river channel Saturn oversees the play of her own two calves and the orphans. From her behavior alone, uniformly doting, you couldn't know which was which.

group dynamics

More than 40 elephant families, whimsically named, each unique, inhabit the Samburu-Laikipia ecosystem. The roster includes these:

THE FIRST LADIES With their leader Eleanor dead, they have lost standing among other groups and may split.

THE PLANETS This large family has subgroups led by Saturn, Gaia, and Dunia (Swahili for Earth).

THE ROYALS They carry birthmarks, showing in some calves as pinkish legs and feet.

THE BIBLICAL TOWNS Babylon, the big, old matriarch, steady and nurturing, holds her family together firmly.

THE VIRTUES Serenity was shot, her orphaned calves later adopted by Rosemary of the Spice Girls.

THE SPICE GIRLS Clover and Rosemary hang tightly together, although they aren't close relatives.

THE WINDS They seem to have synchronized their cycles of calving: Cousins are born about the same time.

THE CLOUDS Tracking data have revealed a special affinity between them and another family, the Storms.

THE POETICS They tend to be smallish, with long, thin tusks. Emily and Sylvia, elderly sisters, serve as co-matriarchs.

REAR GUARD Mistral, one matriarch of the Winds (a large family, now split into three subfamilies), leads her group across the river while a younger female, Sydoest, stands guard at the rear, discouraging a male who seems intent on following. Keen as he may be for female company, the male descends the bank with care, skidding daintily on his knees. Alert but vulnerable, an eight-month-old infant calf (opposite) will grow tusks later.

EXULTATION A mud bath has its utility: cooling, protection against parasites, sunscreen. But utility isn't everything. For this male, hogging the wallow seems cause for exuberance. Anyone who studies these sensitive, intelligent creatures can hardly doubt their capacity for emotion.

(Continued from page 49) dimension—that is, the study of which elephants move where, and when—using global positioning system technology. The spatial study forms a high-tech complement to the low-tech behavioral observations.

DOUGLAS-HAMILTON REMEMBERS the first GPS unit he ever saw in action, brought to Kenya by friends in 1991 and rigged onto an airplane for use in counting elephants within Tsavo National Park. That GPS unit registered only the whereabouts of the airplane, as the plane traced the whereabouts of the animals. Still, he says, "It was quite a revelation to see how the elephants moved and circled—the patterns they adopted." The patterns were important because they reflected informed choices by the elephants as to where they might best satisfy their most urgent imperatives, finding what Douglas-Hamilton calls the three *S*'s: sex, sustenance, and security. GPS technology now offered a way to chart such patterns in detail. "As soon as I saw one of those gadgets," he says, "I wanted to put it on an elephant."

About 20 elephants in the Samburu-Laikipia ecosystem currently wear Save the Elephants GPS collars. The latest model delivers one positional point from each elephant every hour. The technology of the new collars is not only intricate but also economical: To save expense, conserve battery power, and minimize weight, the collar mechanisms receive positional information from GPS satellites but then transmit that information by way of low-cost SMS (short message service) blurts on Safaricom, Kenya's leading cell phone network. In other words, everybody in Kenya has a mobile phone, even the elephants. A few Grevy's zebras are now also transmitting via Safaricom, and who knows what might be next—rock pythons, kori bustards, lilac-breasted rollers? For the present what this means is that each of 20 elephants sends a text message to Douglas-Hamilton's computer, each hour of every day, saying: "Iain, yo, here I am."

Save the Elephants now has GPS tracking projects under way not just in Kenya but also in Mali, South Africa, and the Democratic Republic of the Congo. One important discovery to come from GPS tracking is what Douglas-Hamilton calls "streaking" behavior: the occasional event wherein an elephant or a group of elephants sets out at high speed and travels a long distance in a short time, from one secure area to another, by way of a perilous or at least inhospitable route. A bull known as Shadrack made such a streak—from the green highlands of the Marsabit massif through a town, across the Kaisut Desert, to the Mathews Range of north-central Kenya—covering 50 miles in 36 hours. Another elephant, a female known as Mrs. Kamau, made an even more ambitious streak from Marsabit northeastward, roughly 100 miles in 48 hours, to a solitary zone of lava-paved desert, where she somehow found water and food as well as security in a sere, ragged landscape. Still another male, Mountain Bull, performed an astonishingly discreet series of down-and-back streaks, traveling between the safe northern slopes of Mount Kenya, through a maze of villages, wheat fields, roads, and a safe area along a Laikipia canyon—making this journey not once but 14 times within the space of a year. Each of these animals was a collared representative of what was possibly a whole group of streaking elephants. Their cross-country dashes, recorded by Douglas-Hamilton's system, and interpreted by him collaboratively with a senior scientific colleague, Fritz Vollrath of Oxford University, have helped delineate crucial travel corridors within the Samburu-Laikipia ecosystem.

The data points have been accumulating—about 1.5 million of them by now, forming both the widely spaced dots reflecting high-speed travel and the less dramatic specklings representing smaller scale, quotidian movements. Software created by another young team member, Jake Wall, allows those data to be mapped and animated on Google Earth's vivid topographic Kenya. So if you are Douglas-Hamilton himself, or anyone otherwise privy to the access codes, you can turn on your computer any morning and see which of the collared animals have gone where. You might notice that Mountain Bull has streaked back to Mount Kenya; or that Jerusalem, presumably

We looked up to see the female glowering at us from 70 yards away. Her ears were spread wide. She was agitated. Trumpeting vehemently, she charged.

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accompanied by her five-year-old calf and probably other females of the Biblical Towns, has descended from the safe hillsides south of Samburu and come to water along the Ewaso Ngiro.

And there is uptake by the decision-makers. When I visited the director of the Kenya Wildlife Service, Julius Kipng'etich, at his office in Nairobi, I noticed two maps of Kenya on his wall. One was festooned with blue pins: anti-poaching squads, he said. The other map was crisscrossed with squiggly lines, each line bearing a red directional arrow. "All these red arrows are elephant corridors," the director told me, then added that such data allow him to present good wildlife-management and land-protection advice to the government. As he spoke, I noticed a single red line running northeast from Marsabit far into the desert, and I thought: There goes Mrs. Kamau.

OF THE CARDINAL INCENTIVES that drive elephant behavior—that is, Douglas-Hamilton's three *S*'s: sex, sustenance, and security—the most difficult to calibrate is the third. Finding food, finding water, and finding reproductive opportunities aren't always simple tasks, but compared with finding security they are relatively straightforward. Real security, lasting security, is more unpredictable and elusive. The local people have a word for it: *neebei.* Every person wants neebei—freedom from danger, menace, uncertainty, fear—and it's not anthropomorphism to say that every elephant does too.

Even in northern Kenya, even in the 21st century, with the ivory trade banned and the KWS policing against poachers, the life of an elephant (especially a bull with large tusks) can be precarious. Sometimes an animal is killed by an angry farmer who has seen a crop wrecked, or by an outraged herder who has found a precious cow fatally gored and taken vengeance on the next elephant to appear. Sometimes people still kill for ivory, blasting an elephant full of high-caliber slugs, hacking the face off to wrench out the tusks, moving that ivory into the black market. And sometimes an elephant dies an untimely death for reasons that can't be discovered. When I returned to Kenya for a second visit, after a month away, Douglas-Hamilton told me that Anne, the young female whose collar we inspected on foot, was dead.

She had been shot by persons unknown for reasons unknown. Her tusks, smallish but valuable, hadn't been taken; they were still in place when a KWS patrol found the carcass, by which point they could be pulled from the rotting skull without the need to hack. There was no trace of the perpetrator and no clue to the motive.

A week later I visited Anne's remains, this time with Onesmas Kahindi, the carcass-data man. We found her (with help from Iain, who had flown over the last GPS position and caught a glimpse of white bone) in a soggy, spring-seep valley of western Laikipia, just upstream from a rectangular lake. A cruising vulture lingered nearby, but there wasn't much left to interest it.

Anne's skull, resting beneath a yellow fever tree, was painted with bird dung. Her lower jaw, several ribs, a shoulder blade, and other bone fragments lay scattered about, along with a smear of grassy stomach contents and a patch of dried skin. Her jaw joints showed gnaw marks from

a hyena. The whole area reeked of death, but approaching downwind, we hadn't smelled her until we saw her. She had been dead about three weeks. The maggots and flies, like the hyenas, had already come and gone. Kahindi measured a molar. He snapped a photo. The sky began darkening toward an afternoon shower as he recorded his data.

Anne had made her choices, and one choice brought her to this little valley, probably for its water and good grass. Whatever else she found, she hadn't found neebei, but the details of her misfortune were inscrutable. Kahindi, a tireless worker for elephant conservation but no sentimentalist, capped his pen. "Finished," he said. "OK, let's beat the rain."

IT'S ALL ABOUT CHOICES. Elephants are smart, they know what they need, and they generally know where to get it; if they don't know, their mother or grandmother will teach them. They seem to calculate risks. They can be dangerous, but they prefer to avoid conflict with other big, dangerous creatures such as lions or people. They are herbivores, after all, with no reasons to kill except defense, confusion, panic, and desperation when their needs are unmet. In the Samburu-Laikipia ecosystem they manage to live in the spaces between human farms and settlements with far lower levels of conflict and higher levels of mutual tolerance than exist in most other areas where elephants range. Douglas-Hamilton talked thoughtfully to me about such things, both before and after the day I nearly got him killed by an elephant.

It happened like this. Late one afternoon, he stopped by my tent and asked: Want to drive out and see some elephants before sunset? He often rewarded himself that way for eight hours' deskbound effort. On this occasion I said: How about a walk instead? I knew that foot travel within the reserve was generally inadvisable, but couldn't we at least climb the little conical hill just behind camp? Yes indeed, he said; and so we did. From the hill's rocky top we savored a magnificent view westward, with the brown slick of the Ewaso Ngiro winding its way downstream between banks bristling with palm and acacia. Just north of us was a larger hill, a double mound known as Sleeping Elephant. Have you ever climbed that one? I asked. No, said Douglas-Hamilton, with a mischievous glint in his eye… but we could.

Thus we set out on foot toward Sleeping Elephant: two middle-aged white men and a young Samburu from the camp crew, a skinny lad named Mwaniki, in his beads and his shuka, whom Douglas-Hamilton asked to tag along. We walked only five minutes through the high, sparse brush before we saw elephants ahead: a female with two calves. We paused, admiring them from a safe distance until they seemed to withdraw, and then we went on. Seconds later Mwaniki muttered a warning, and we looked up to see the female glowering at us from 70 yards away. Her ears were spread wide. She was agitated. Seventy yards might sound like a long distance, but in personal space for an elephant, it isn't. Trumpeting vehemently, she charged.

I turned and ran like a fool. Mwaniki turned and ran like a gazelle. Douglas-Hamilton turned and ran—then thought better of it, turned, threw his arms out, and hollered to stop her. Sometimes this works; some elephants (such as old Boadicea, back at Manyara) make bluff charges, or half-hearted ones, and can be halted by a gutsy challenge. But this charge wasn't bluff. The female honked again and kept coming. Douglas-Hamilton turned again and ran.

By this time I had a 20-step lead and Mwaniki was gone. At the rate he'd been moving, he might have been halfway to Lamu. But no: He ran straight back into camp (we learned afterward) and shouted in Samburu: *"Etara lpayian ltome!"* Meaning: The old man has been killed by an elephant! This announcement, though premature, brought people back to the scene fast.

Meanwhile the elephant caught Douglas-Hamilton as he tried to evade her by circling a bush. From 50 feet away I watched her lift him with her trunk and then toss him, as you'd toss dirt off a shovel. He uttered a single piteous word: "Help." She stepped forward and stabbed her tusks downward. Douglas-Hamilton's body

His little Cessna is a tool by which to see and know elephants. It's also a pleasure. After 40 years and 6,000 piloting hours, Douglas-Hamilton soars over the landscape, deft and curious as an African pied crow.

was now obscured by tall grass, and I couldn't see whether she had nailed him. Then she backed off about ten steps and paused. This was the moment, he told me later, when he had time to wonder whether he would die.

She turned away. She marched off to find her calves.

I ran back to Douglas-Hamilton, and to my surprise, his innards weren't hanging out like ratatouille. He was scratched, dazed, bruised, rumpled; his shoes, glasses, and watch were gone; but he was OK. I felt all over his rib cage: no tusk holes. Between us, we got him to his feet. And then a dozen people arrived, running and driving from camp. Someone found his glasses and shoes. The watch was busted but ticking. Quickly we vacated the area, lest the elephant change her mind and come back.

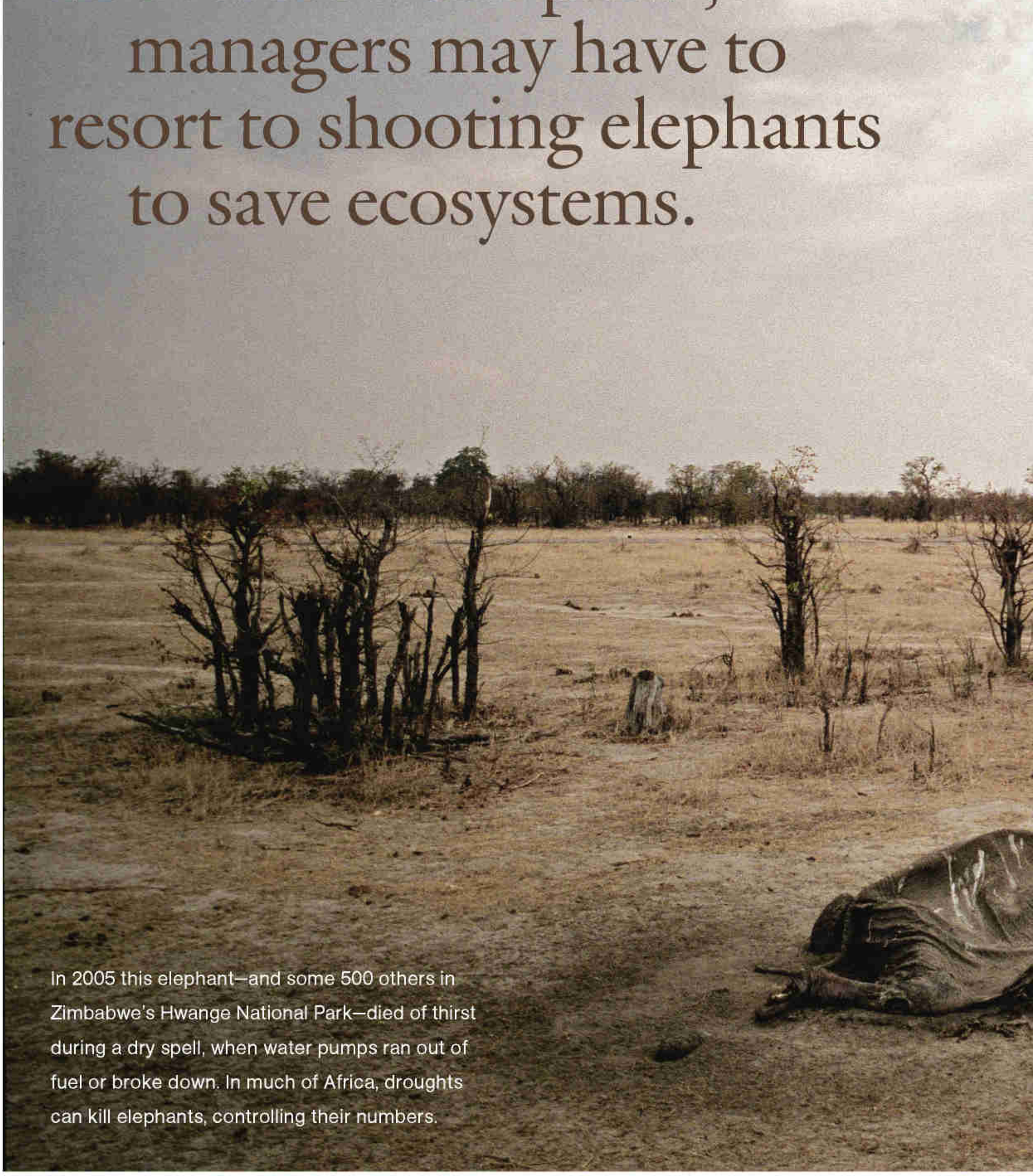
In the aftermath Douglas-Hamilton and I pieced together what had happened. There was much relief, much apologizing (especially by me, for getting us out there on foot, but he wouldn't hear of that and claimed the blame himself), and much hypothesizing. With help from Daballen and Lentipo, he established that this female must have been Diana, of the Royals, with her two youngish calves. Maybe we startled her because the wind had been at her back; therefore she couldn't smell us before we got near. Maybe she feared for her calves. Maybe she had been put on edge by a pushy bull, or a lion, just before we blundered along. Is there anything in the records on Diana, he asked his people, that would suggest a recalcitrant disposition? There was not.

Diana. She was "just" another elephant: sensitive, volatile, and complex. Her behavior that afternoon, though violent, had been nuanced. At the last moment she made a choice. She chose not to kill him. And no one, not even Iain Douglas-Hamilton, with all his magical gadgetry and his hard-won knowledge, will ever know why. □

Posing Pachyderms Watch photographer Michael Nichols put elephants at ease—they even napped by his jeep—in a video at **ngm.com.**

desperate measure

In overcrowded parks, managers may have to resort to shooting elephants to save ecosystems.



In 2005 this elephant—and some 500 others in Zimbabwe's Hwange National Park—died of thirst during a dry spell, when water pumps ran out of fuel or broke down. In much of Africa, droughts can kill elephants, controlling their numbers.

GARY KNIGHT, VII

BY KAREN E. LANGE
NATIONAL GEOGRAPHIC STAFF

TOWARD THE COOL OF EVENING the helicopter took off, vultures trailing in its wake. The pilot approached the elephants from behind, coming in low over their backs to give the marksman a clear shot to the brain with his semiautomatic rifle. One bullet was usually enough. First the matriarch—the group's leader, the repository of collective wisdom—went down, and then the younger females and calves were picked off as they huddled around her body. Every member of the group was killed; any survivors would be too devastated by the loss of their closest companions to function normally. Immediately after the aerial assault, a ground crew arrived to shoot the rare elephant that was still alive. The carcasses were gutted, and the skin, meat, and tusks trucked away for processing at the abattoir in South Africa's Kruger National Park. Only the innards—and bloodied ground—were left behind.

To restrain the growth of Kruger's elephant population, 14,562 animals were culled from 1967 to 1995, when South Africa banned the practice. "It was extraordinarily traumatic," says Ian Whyte, the park's longtime elephant specialist, who witnessed many of the culls. "You had to shut your mind to it, otherwise you'd go mad."

Now elephant specialists are being forced to consider culling again. While poaching continues to threaten elephants in Kenya and elsewhere, in southern Africa conservation measures have been so successful that populations are booming. In the 13 years since South Africa's culling ban, Kruger's elephants have increased from 8,000 to more than 13,000. The elephants, each eating about 400 pounds of food a day, are transforming the landscape, tearing through vegetation, pulling down or uprooting trees and stripping them of bark. Hungry elephants, combined with wildfires that consume downed trees and saplings, are converting some parts of the park from wooded savanna to scrub grassland, providing habitat for grazers such as zebras but destroying nesting places for eagles and other birds.

So South Africa's Department of Environmental Affairs and Tourism (DEAT) recently convened the Elephant Science Round Table—18 internationally recognized experts, most from South Africa—to consider how to manage growing populations and whether culling should again be an option. One objection: The practice would increase stockpiles of ivory, raising pressures to end the international ban on ivory sales that has been in force since 1989. If the ban ended, the market for tusks would heat up, and so would elephant poaching. Another objection: It would thwart natural processes. Kenya's Iain Douglas-Hamilton says, "In some cases I'd rather see a population collapse through starvation than see it culled." But zoologist John Hanks, a consultant with International Conservation Services, says that in certain situations, and as a last resort, park managers may need to cull to protect biodiversity. "We've created a highly artificial situation by restricting elephants to parks."

In the end the experts agreed that culling is not immediately necessary in Kruger but should be allowed again in South Africa if nothing else can stop elephants from eliminating habitat other animals depend on—a recommendation enshrined in the country's new elephant management policy, which took effect in May. The policy recognizes the animals' "sentient nature, highly organized social structure, and ability

From a helicopter, a veterinarian tranquilizes the matriarch of a family group (top) in Mozambique. She'll be fitted with a radio collar to track her, helping managers find areas that dense concentrations of elephants can spill into. A surplus Kruger bull (right) is being translocated; some 2,200 elephants have been trucked to less crowded parks.

to communicate" but allows culling as a last resort. Getting approval to cull in any location would take months, maybe years. Michele Pickover, an activist with South Africa–based Animal Rights Africa, predicts that her country won't allow culling until after it hosts the 2010 soccer World Cup, for fear of tarnishing its international image.

One way to avoid killing elephants is to dart females with contraceptives. The procedure can cost more than $150 per elephant and must be done repeatedly. In a large park like Kruger, contraception would be hugely expensive and difficult, but it's being used successfully in smaller protected areas, such as Makalali Private Game Reserve, with about 70 elephants.

Translocation—trucking surplus elephants out of overpopulated areas—is also costly, and South Africa has few places left that are large enough to accommodate an influx of elephants. Most of the roughly 30 small reserves that have accepted elephants from Kruger since 1979 are now struggling to manage their growing numbers.

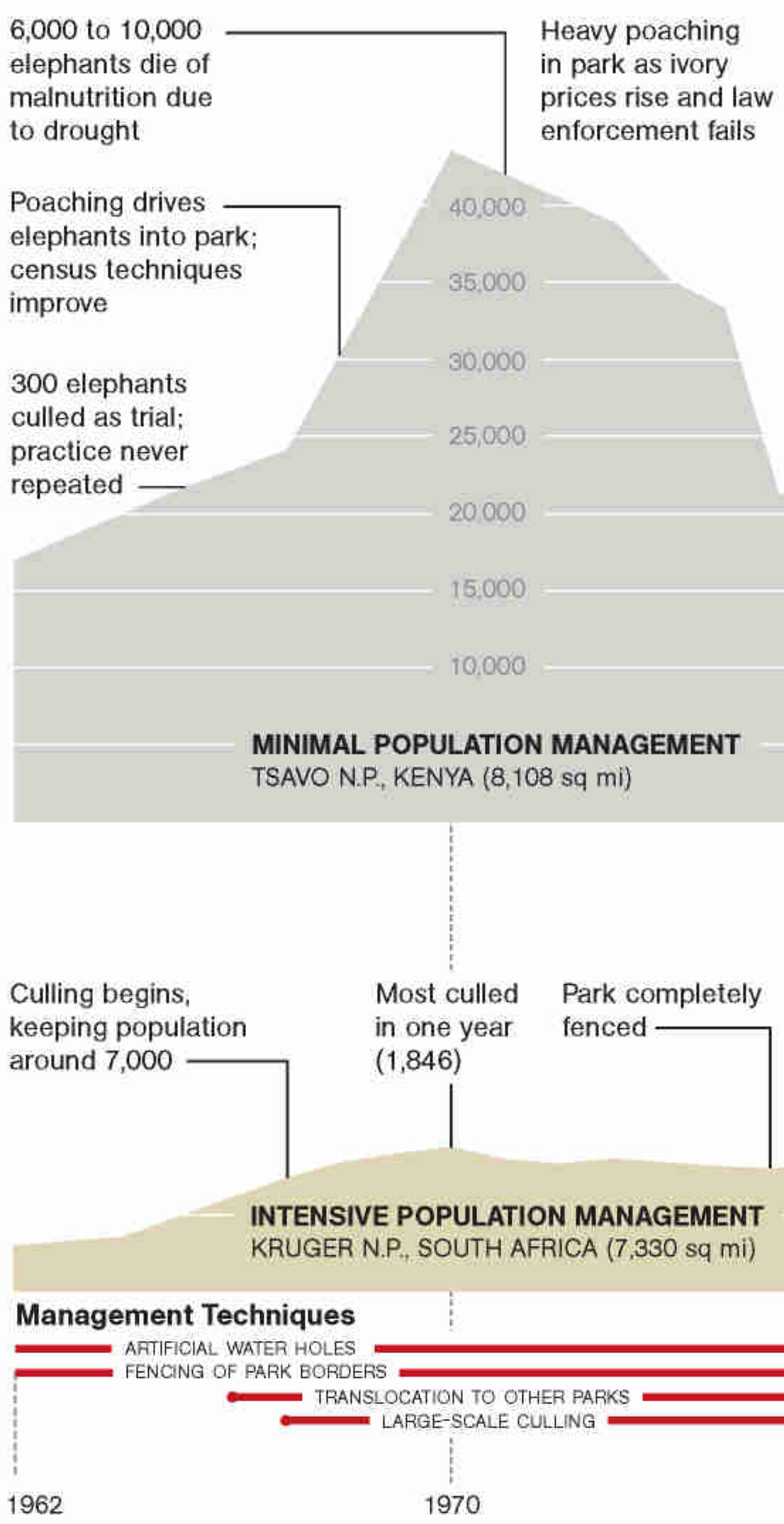
Rudi van Aarde, of the University of Pretoria, and other roundtable experts favor a multipronged solution to the population problem: get rid of artificial water supplies, which allow elephants to survive droughts that keep populations in check and which concentrate herds in one spot; take down park fences; and establish corridors and megaparks so that elephants can disperse across a larger landscape, reducing seasonal and long-term pressures on habitats. (Van Aarde acknowledges that if newly occupied areas get overcrowded, it may become necessary to permit local

A Kruger elephant culled in 1994 was processed into dried and canned meat at this abattoir. After a 13-year hiatus, the killing may begin again.

people to hunt a certain number of elephants.)

Kruger has taken down fences along some of its borders, allowing elephants to migrate west into private reserves and east into Mozambique's Limpopo National Park, a drier region where the animals are still scarce. Limpopo should act as a safety valve for at least the next five to ten years, says Norman Owen-Smith of the University of the Witwatersrand. Others note that people living in Limpopo have already complained about elephants damaging their crops.

The free-range approach is also alleviating pressures in countries neighboring South Africa. Northern Botswana's more than 150,000 elephants—Africa's largest population—are roaming in and out of Zimbabwe and reclaiming areas in Angola and Namibia from which they were driven by war and poaching. The once steep growth curve of the Botswana population is flattening, and Michael Chase, a researcher with Botswana-based Elephants Without Borders, estimates it will be at least 20 years before it climbs again. Nevertheless Botswana's elephants, up from perhaps 8,000 in 1960, are very dense in some areas, such as along a 12-mile stretch of the Chobe River, where they've destroyed most of the trees. A proposed new regional management plan includes the possibility of culling. In Zimbabwe, the government says the elephant population has risen from 46,000 in 1980 to more than 100,000 today, claiming that is twice as many as the land can support. In the past two



CHRIS JOHNS, NATIONAL GEOGRAPHIC IMAGE COLLECTION

years it has allowed nearly 150 elephants to be shot for meat. Critics respond that Zimbabwe simply wants to kill elephants for their ivory, and indeed government officials have been accused of illegally exporting tusks to China in an ivory-for-arms deal.

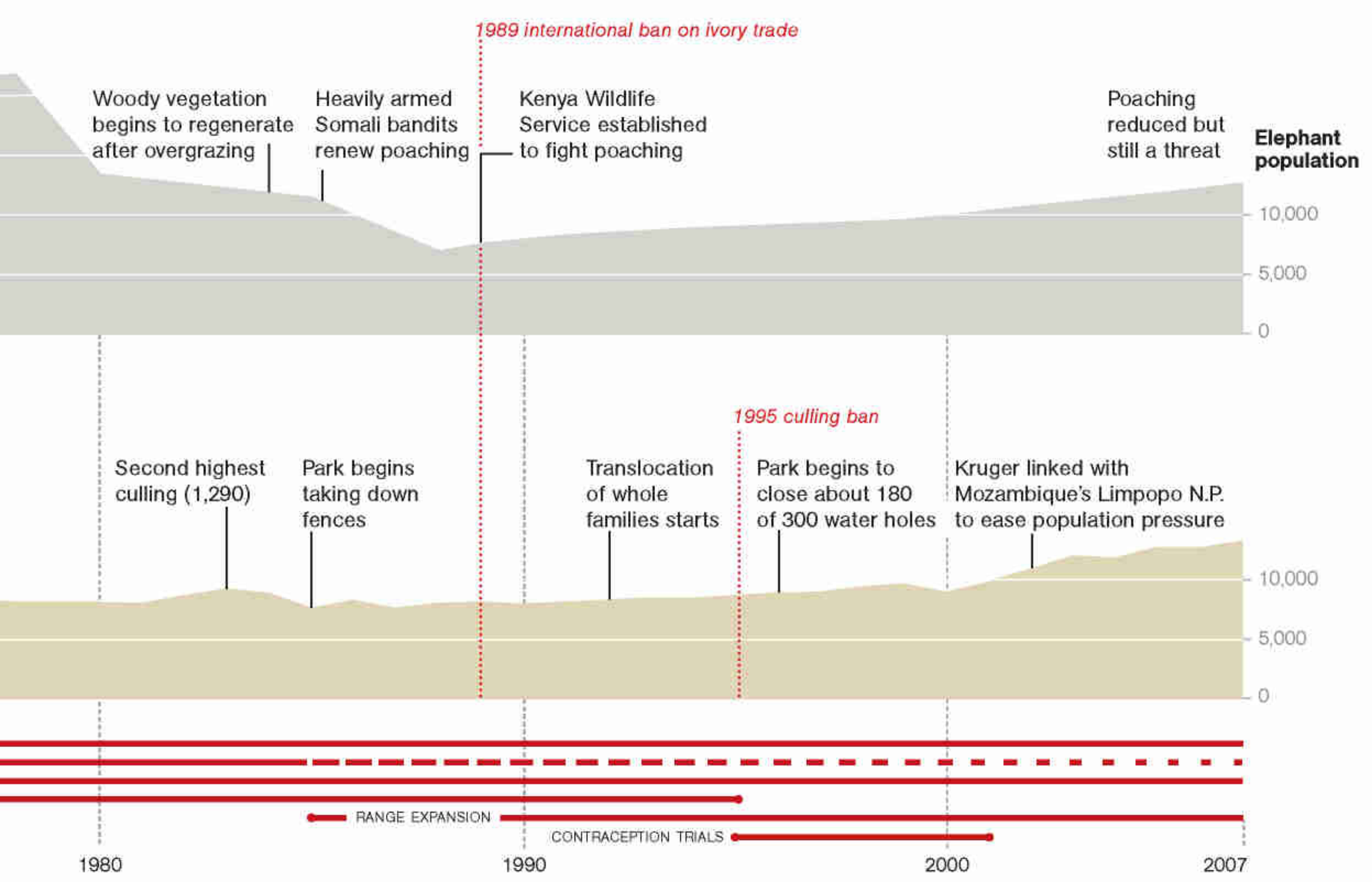
When culling resumes in South Africa, it will likely not be in Kruger but in smaller parks, those between 200 and 400 square miles that have populations too large to be easily controlled by contraception or translocation and are too compact and bounded by human settlement for their elephants to migrate outside. Rob Slotow of the University of KwaZulu-Natal believes that in most cases it will be possible to avoid culling. But, he says, in Tembe Elephant Park, with its rare sand forest vegetation, it may eventually become necessary to shoot bulls that cause irreparable habitat damage.

Ian Whyte, who recently retired from Kruger, says he's glad he'll no longer have to take part in what he sees as inevitable: "Culling has to happen at some stage," he says. "I can't imagine it will be a long time." □

Conflict Resolution Learn how scientists are using bees, bells, and mobile phones to lessen elephant-human tensions at **ngm.com.**

TSAVO AND KRUGER: TWO MORTAL CHOICES

Decades of radically different management have left these similar-size parks with nearly equal elephant populations but divergent challenges. Tsavo grapples with poaching, while Kruger confronts crowding.



M. BRODY DITTEMORE AND LISA R. RITTER, NG STAFF. SOURCES: IAIN DOUGLAS-HAMILTON, SAVE THE ELEPHANTS; MOSES LITOROH AND PATRICK OMONDI, KENYA WILDLIFE SERVICE; BOB SCHOLES AND KATHLEEN MENNELL, COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH, SOUTH AFRICA; SOUTH AFRICAN NATIONAL PARKS; IAN WHYTE

in the whirl

PHOTOGRAPHS BY PAUL NICKLEN

Adorned for the hunt, with fin raised and changeable colors flashing, a sailfish in the Gulf of Mexico circles a ball of sardines, preparing to strike.

Hunters gather: More than a hundred sailfish keep tabs on an elephant-size school of sardines off Mexico's Isla Mujeres. The big fish, which can stretch eight feet tip to tip, drive their prey up from deeper water for easier feeding near the sunlit surface.

Wielding its bony bill, the predator slices through a sardine school to isolate a smaller cluster—more controllable as the prey zigzag to elude capture. Sardines seek safety in numbers, moving as one.

BY JENNIFER S. HOLLAND
NATIONAL GEOGRAPHIC STAFF

The hunt is on. Fifty miles northeast of Isla Mujeres in the Gulf of Mexico, sailfish prowl through blue waters.

Frigatebirds hang like arrows above the sea, dipping down now and then to grab a meal. Following their lead, Anthony Mendillo, sportfishing guide and expert sailfish chaser, steers the *Keen M* toward the flocks. Sure enough, below the birds a school of sardines hundreds strong moves as one, flashing in the sun with each turn. Dozens of long shadows orbit the ball of frantic fish: the hunters.

Sailfish and sardines are migratory and widely distributed, with populations in multiple oceans. But from January into June, *Istiophorus platypterus* and *Sardinella aurita* meet fish to fish in this stretch of sea. For predator and prey the continental shelf here makes ideal habitat. Plankton-rich shallows, nourished by rivers draining the mainland and ocean currents pushing between Cuba and the Yucatán, promise ample food.

The hunt seems almost mammalian. Sailfish—which often travel in loose groups—clearly join forces. Males and females alike circle the prey, pushing the school into tighter formation, and taking a few bites in turn. Each forward rush is punctuated by a startling flare of the dorsal fin, which more than doubles the hunter's profile.

An iridescent flash along the body, often in silvery blue stripes, adds to the effect. Darkly pigmented cells called melanophores are "like venetian blinds," says neurobiologist Kerstin Fritsches of the University of Queensland, in Australia. Ordinarily the animal appears dull, but "during stress or excitement, the cells contract their pigment to expose gorgeous metallic colors in the skin below."

Color bursts may serve not only to unsettle prey but also to warn other sailfish to stay back, helping avoid collisions. "Given their pointy noses and swimming speed, this would be important," Fritsches says. Indeed, sailfish bills—elongated upper jaws that the hunters whip left and right to batter prey, and likely wield against sharks, marlins, and other enemies—are dagger sharp. Yet despite their rapid-fire strikes, reports of sailfish skewering one another are hard to find. The fish take turns—and it appears no one loses an eye or goes hungry in the frenzy.

The sardines, too, work in concert. Detecting each other's proximity and movement, they shift in synchrony, each fish both leader and follower. The fish mass slides like a drop of mercury, mesmerizing, with a shimmer that may help to confuse predators.

But no hypnotic dance can fully protect the sardines, which will hide in a squirming mass under any bit of flotsam—even a snorkeler. The sailfish simply wait within striking distance for their prey to be exposed. Soon the hunt is back on, predators again corralling, swatting, swallowing. After a rush to mop up the leftovers, the deadly game is over, and the sailfish retreat. In their wake, drifts of glinting sardine scales fall slowly into the blue.

Canadian-born Paul Nicklen has photographed leopard seals and other powerful ocean hunters.

Like wolves on a caribou herd, sailfish cooperate—sometimes for several hours—to turn unwieldy prey into a manageable meal. The predators shoot in from all sides, popping open fins and flashing iridescent colors as they get up close. "It's like saying, Boo! I'm here!" says marine scientist Guy Harvey, a longtime sailfish observer. "There's a shock effect that pushes prey together." Once a ball is under control, the sailfish take turns shooting through it, heads whipping side to side as they use their bills to bat sardines (center) with remarkable precision. Pursuers then nab stunned fish before they can escape. Whittled down to its last bloody stragglers, the ball spins in a slow vortex (bottom), prey exhausted and no longer in perfect concert. Typically sailfish will consume every last one.

Feeding Frenzy Watch sailfish make short work of a sardine ball at **ngm.com.**

Splashing back into the sea after breaching the surface in pursuit of prey, this sailfish snapped up a sardine that had become separated from its school. With prey still at large, the predator will soon head back into the whirl. □

Our Good Earth

The future rests on the soil beneath our feet.

A late-summer patchwork of trees, mowed hay fields, and standing corn follows the contours of Wisconsin's Coon Creek watershed. Once ravaged by erosion, its farms and streams became a national showcase for soil conservation strategies in 1933.

Can we save it?

In northern China's Loess Plateau the edges of terraced fields routinely collapse down steep gullies. Farming on this fragile silt contributes to one of the world's highest erosion rates.

Virgin Prairie

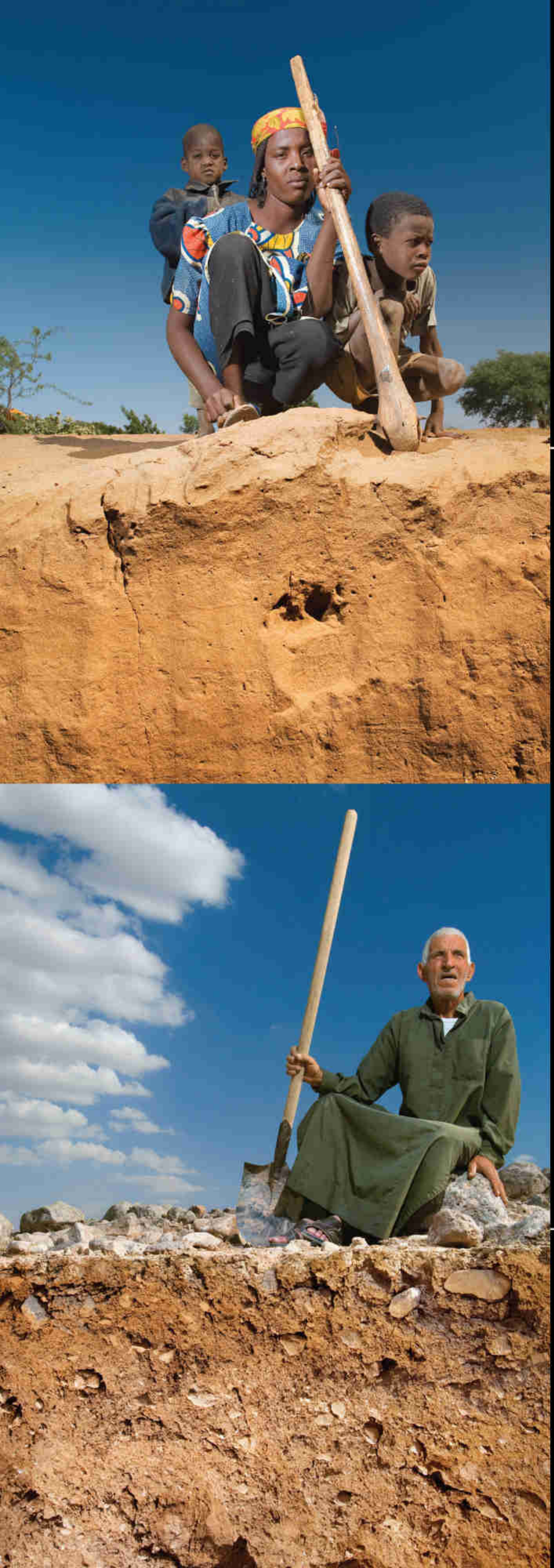
KANSAS, UNITED STATES

Rancher Jim Duggan holds a stalk of big bluestem, one of the native grasses growing on 40 acres of his farmland that have never been plowed. “This land is the best there is,” he says. “It’s class-one river-bottom soil.” Compared with tilled fields, the parcel has deeper, richer topsoil and soaks up more rain.

Rice Terrace

YUNNAN PROVINCE, CHINA

Perched on an earthen retaining wall, Zhu Minying holds cords used to bundle harvested rice. Soil here reflects human activities that began with reshaping hillsides into grand staircases of grain. Rice stubble left to decay in the field, manure, and fish raised in the paddy water, all add nutrients to Zhu’s soil.



Reclaimed Fields

KEITA DISTRICT, NIGER

Mariama Abdoulaye feeds her family with millet she grows on once barren land. After severe droughts in the 1970s and '80s, the UN Food and Agricultural Organization enlisted Abdoulaye and 10,000 other women to plant millions of trees. Tree roots block wind-driven erosion and help rain penetrate the earth.

Dry Land

KHANASSER VALLEY, SYRIA

Farmers like Ismail Hassoun Hariri struggle to grow even hardy barley in this parched land. Soil and rock eroded from surrounding hills lie thick in the valley, but annual rainfall averages only nine inches. In some very dry years the barley crop fails to mature and can only be used to feed sheep and goats.

BY CHARLES C. MANN

PHOTOGRAPHS BY JIM RICHARDSON

On a warm September day, farmers from all over the state gather around the enormous machines. Combines, balers, rippers, cultivators, diskers, tractors of every variety—all can be found at the annual Wisconsin Farm Technology Days show. But the stars of the show are the great harvesters, looming over the crowd. They have names

like hot rods—the Claas Jaguar 970, the Krone BiG X 1000—and are painted with colors bright as fireworks. The machines weigh 15 tons apiece and have tires tall as a tall man. When I visited Wisconsin Farm Technology Days last year, John Deere was letting visitors test its 8530 tractor, an electromechanical marvel so sophisticated that I had no idea how to operate it. Not to worry: The tractor drove itself, navigating by satellite. I sat high and happy in the air-conditioned bridge, while beneath my feet vast wheels rolled over the earth.

The farmers grin as they watch the machines thunder through the cornfields. In the long run, though, they may be destroying their livelihoods. Midwestern topsoil, some of the finest cropland in the world, is made up of loose, heterogeneous clumps with plenty of air pockets between them. Big, heavy machines like the harvesters mash wet soil into an undifferentiated, nigh impenetrable slab—a process called compaction. Roots can't penetrate compacted ground; water can't drain into the earth and instead runs off, causing erosion. And because compaction can occur deep in the ground, it can take decades to reverse. Farm-equipment companies, aware of the problem, put huge tires on their machines to spread out the impact. And farmers are using satellite navigation to confine vehicles to specific paths, leaving the rest of the soil untouched. Nonetheless, this kind of compaction remains a serious issue—at least in nations where farmers can afford $400,000 harvesters.

Unfortunately, compaction is just one, relatively small piece in a mosaic of interrelated problems afflicting soils all over the planet. In the developing world, far more arable land is being lost to human-induced erosion and desertification, directly affecting the lives of 250 million people. In the first—and still the most comprehensive—study of global soil misuse, scientists at the International Soil Reference and Information Centre (ISRIC) in the Netherlands estimated in 1991 that humankind has degraded more than 7.5 million square miles of land. Our species, in other words, is rapidly trashing an area the size of the United States and Canada combined.

This year food shortages, caused in part by the diminishing quantity and quality of the world's soil (see "Dirt Poor," page 108), have led to riots in Asia, Africa, and Latin America. By 2030, when today's toddlers have toddlers of their own, 8.3 billion people will walk the Earth; to feed them, the UN Food and Agriculture Organization estimates, farmers will have to

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Staple food for half the people on Earth, rice has grown in paddies like this one in China's Yunnan Province for centuries. Within paddy walls standing water shields soil from drying and erosion. Protecting and improving soils becomes more crucial as world food needs grow.

Even as humankind is ratchetting up its demands on soil, we are destroying it faster than ever before.

grow almost 30 percent more grain than they do now. Connoisseurs of human fecklessness will appreciate that even as humankind is ratchetting up its demands on soil, we are destroying it faster than ever before. "Taking the long view, we are running out of dirt," says David R. Montgomery, a geologist at the University of Washington in Seattle.

Journalists sometimes describe unsexy subjects as MEGO: My eyes glaze over. Alas, soil degradation is the essence of MEGO. Nonetheless, the stakes—and the opportunities—could hardly be higher, says Rattan Lal, a prominent soil scientist at Ohio State University. Researchers and ordinary farmers around the world are finding that even devastated soils can be restored. The payoff, Lal says, is the chance not only to fight hunger but also to attack problems like water scarcity and even global warming. Indeed, some researchers believe that global warming can be slowed significantly by using vast stores of carbon to reengineer the world's bad soils. "Political stability, environmental quality, hunger, and poverty all have the same root," Lal says. "In the long run, the solution to each is restoring the most basic of all resources, the soil."

WHEN I MET ZHANG LIUBAO in his village in central China last fall, he was whacking the eroded terraces of his farm into shape with a shovel—something he'd been doing after every rain for more than 40 years. In the 1960s, Zhang had been sent to the village of Dazhai, 200 miles to the east, to learn the Dazhai Way—an agricultural system China's leaders believed would transform the nation. In Dazhai, Zhang told me proudly, "China learned everything about how to work the land." Which is true, but not, alas, in the way Zhang intended.

Dazhai is in a geological anomaly called the Loess Plateau. For eon upon eon winds have swept across the deserts to the west, blowing grit and sand into central China. The millennia of dust fall have covered the region with vast heaps of packed silt—loess, geologists call it—some of them hundreds of feet deep. China's Loess Plateau is about the size of France, Belgium, and the Netherlands combined. For centuries the silt piles have been washing away into the Yellow River—a natural process that has exacerbated, thanks to the Dazhai Way, into arguably the worst soil erosion problem in the world.

After floods ravaged Dazhai in 1963, the village's Communist Party secretary refused any aid from the state, instead promising to create a newer, more productive village. Harvests soared, and Beijing sent observers to learn how to replicate Dazhai's methods. What they saw was spade-wielding peasants terracing the loess hills from top to bottom, devoting their rest breaks to reading Mao Zedong's little red book of revolutionary proverbs. Delighted by their fervor, Mao bused thousands of village representatives to the settlement, Zhang among them. The atmosphere was cultlike; one group walked for two weeks just to view the calluses on a Dazhai laborer's hands. Mainly Zhang learned there that China needed him to produce grain from every scrap of land. Slogans, ever present in Maoist China, explained how to do it: Move Hills, Fill Gullies, and Create Plains! Destroy Forests, Open Wastelands! In Agriculture, Learn From Dazhai!

Zhang Liubao returned from Dazhai to his home village of Zuitou full of inspiration. Zuitou was so impoverished, he told me, that people ate just one or two good meals a year. Following Zhang's instructions, villagers fanned out, cutting the scrubby trees on the hillsides, slicing the slopes into earthen terraces, and planting millet on every newly created flat surface. Despite constant hunger, people worked all day and then lit lanterns and worked at night. Ultimately, Zhang said, they increased Zuitou's farmland by "about a fifth"—a lot in a poor place.

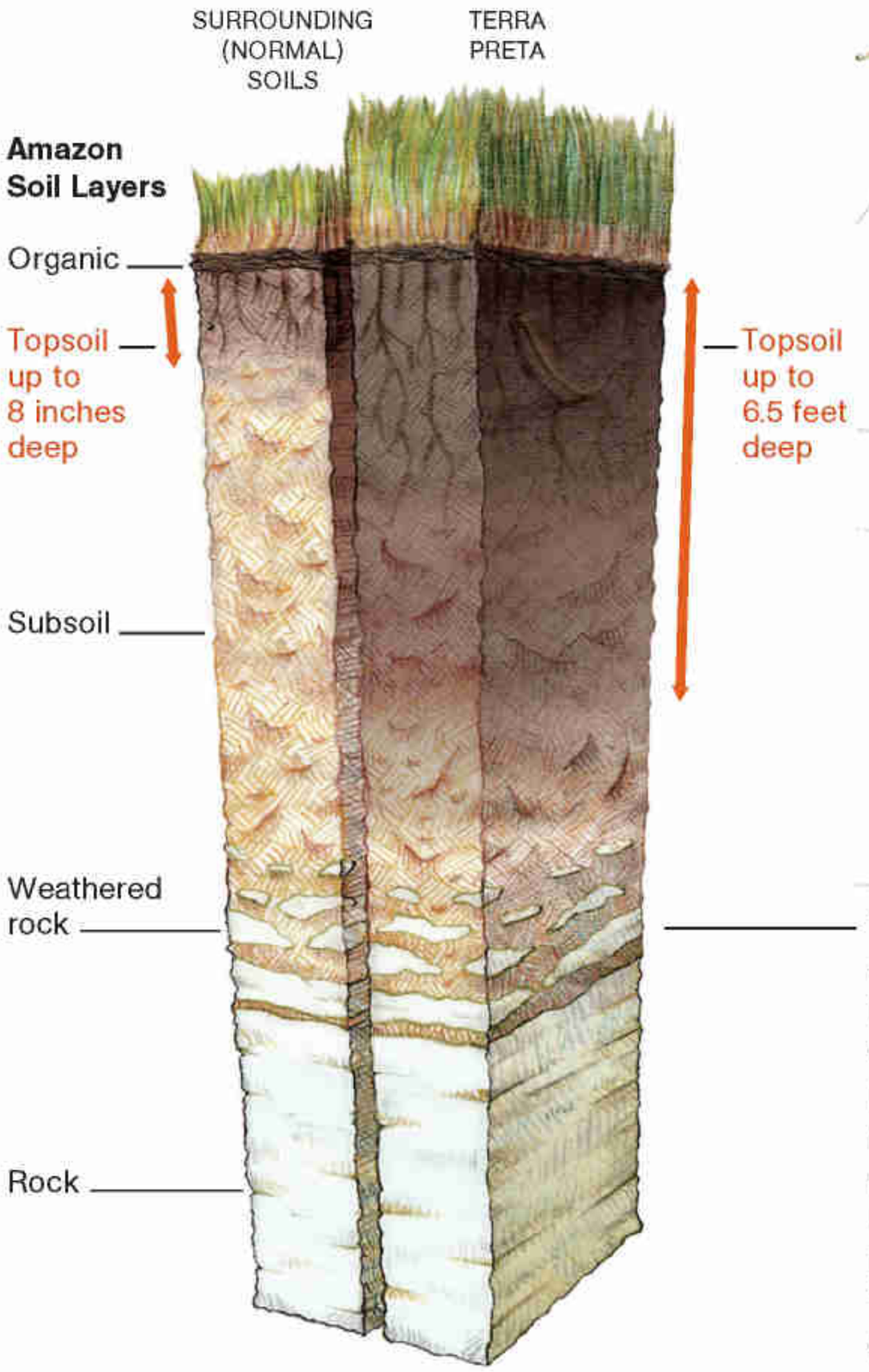
Alas, the actual effect was to create a vicious circle, according to Vaclav Smil, a University of Manitoba geographer who has long studied China's environment. Zuitou's terrace walls, made of nothing but packed silt, continually fell apart; hence Zhang's need to constantly shore

Syria's "dead cities" perished centuries ago, in part because forests were cut and replaced by olive groves, says soil scientist John Ryan. Rain-driven erosion followed. "If there's no soil to absorb rain, springs don't flow," Ryan says. "You need soil and water to sustain people."

Scarce Fertility

Today more than six billion people rely on food grown on just 11 percent of the global land surface. Even less ground—a scant 3 percent of the Earth's surface—offers inherently fertile soil (dark and medium green areas, below). Soil degradation can transform productive zones into wastelands with tragic speed. "The history of every nation," U.S. President Franklin Roosevelt said, "is eventually written in the way in which it cares for its soil."

Terra Preta do Índio—Black Indian Earth
Between 2,500 and 500 years ago in the Amazon Basin, people created deep layers of carbon-enriched earth, enhancing the fertility of poor, shallow soils.



Terra preta sites
Archaeologists have identified pockets of rich topsoil that built up as charcoal, along with food refuse and other wastes, including broken pottery, was mixed into stingy soils. The deposits range in size from two or three acres (typical) to as much as 30 to 40 acres.

HIGHLY FERTILE
In the world's breadbaskets, mild temperatures and adequate rainfall help sustain exceptionally productive soils, ideal for annual crops.

HIGHLY FERTILE AT RISK
These naturally fertile soils are vulnerable to human mismanagement, which can lead to compaction, erosion, and desertification.

MARGINAL
Soils here are on the cusp, with agricultural productivity largely dependent on human choices: People can either nurture the soil or degrade it.

MAP BY VIRGINIA W. MASON, NG STAFF
ART BY CHARLES M. BLOW

SOURCES: USDA NATURAL RESOURCES CONSERVATION SERVICE; GERHARD BECHTOLD; JOHANNES LEHMANN, CORNELL UNIVERSITY

up collapsing terraces. Even when the terraces didn't erode, rains sluiced away the nutrients and organic matter in the soil. After the initial rise, harvests started dropping. To maintain yields, farmers cleared and terraced new land, which washed away in turn.

The consequences were dire. Declining harvests on worsening soil forced huge numbers of farmers to become migrants. Partly for this reason, Zuitou lost half of its population. "It must be one of the greatest wastes of human labor in history," Smil says. "Tens of millions of people forced to work night and day on projects that a child could have seen were a terrible stupidity. Cutting down trees and planting grain on steep slopes—how could that be a good idea?"

In response, the People's Republic initiated plans to halt deforestation. In 1981 Beijing ordered every able-bodied citizen older than 11 to "plant three to five trees per year" wherever possible. Beijing also initiated what may still be the world's biggest ecological program, the Three Norths project: a 2,800-mile band of trees running like a vast screen across China's north, northeast, and northwest, including the frontier of the Loess Plateau. Scheduled to be complete in 2050, this Green Wall of China will, in theory, slow down the winds that drive desertification and dust storms.

Despite their ambitious scope, these efforts did not directly address the soil degradation that was the legacy of Dazhai. Confronting that head-on was politically difficult: It had to be done without admitting Mao's mistakes. (When I asked local officials and scientists if the "Great Helmsman" had erred, they changed the subject.) Only in the past decade did Beijing chart a new course: replacing the Dazhai Way with what might be called the Gaoxigou Way.

Gaoxigou (Gaoxi Gully) is west of Dazhai, on the other side of the Yellow River. Its 522 inhabitants live in *yaodong*—caves dug like martin nests into the sharp pitches around the village. Beginning in 1953, farmers marched out from Gaoxigou and with heroic effort terraced not mere hillsides but entire mountains, slicing them one after another into hundred-tier wedding cakes iced with fields of millet and sorghum and corn. In a pattern that would become all too familiar, yields went up until sun and rain baked and blasted the soil in the bare terraces. To catch eroding loess, the village built earthen dams across gullies, intending to create new fields as they filled up with silt. But with little vegetation to slow the water, "every rainy season the dams busted," says Fu Mingxing, the regional head of education. Ultimately, he says, villagers realized that "they had to protect the ecosystem, which means the soil."

Today many of the terraces Gaoxigou laboriously hacked out of the loess are reverting to nature. In what locals call the "three-three" system, farmers replanted one-third of their land—the steepest, most erosion-prone slopes—with grass and trees, natural barriers to erosion. They covered another third of the land with harvestable orchards. The final third, mainly plots on the gully floor that have been enriched by earlier erosion, was cropped intensively. By concentrating their limited supplies of fertilizer on that land, farmers were able to raise yields enough to make up for the land they sacrificed, says Jiang Liangbiao, village head of Gaoxigou.

In 1999 Beijing announced it would deploy a Gaoxigou Way across the Loess Plateau. The Sloping Land Conversion Program—known as

The roots of this Indian grass reached ten feet into Kansas earth, anchoring prairie soil and leaking plant sugars that nourished fertility-enhancing microorganisms. One acre of roots can weigh as much as a school bus.

"grain-for-green"—directs farmers to convert most of their steep fields back to grassland, orchard, or forest, compensating them with an annual delivery of grain and a small cash payment for up to eight years. By 2010 grain-for-green could cover more than 82,000 square miles, much of it on the Loess Plateau.

But the grand schemes proclaimed in far-away Beijing are hard to translate to places like Zuitou. Provincial, county, and village officials are rewarded if they plant the number of trees envisioned in the plan, regardless of whether they have chosen tree species suited to local conditions (or listened to scientists who say that trees are not appropriate for grasslands to begin with). Farmers who reap no benefit from their work have little incentive to take care of the trees they are forced to plant. I saw the entirely predictable result on the back roads two hours north of Gaoxigou: fields of dead trees, planted in small pits shaped like fish scales, lined the roads for miles. "Every year we plant trees," the farmers say, "but no trees survive."

Some farmers in the Loess Plateau complained that the almonds they had been told to plant were now swamping the market. Others grumbled that Beijing's fine plan was being hijacked by local officials who didn't pay farmers their subsidies. Still others didn't know why they were being asked to stop growing millet, or even what the term "erosion" meant. Despite all the injunctions from Beijing, many if not most farmers were continuing to plant on steep slopes. After talking to Zhang Liubao in Zuitou, I watched one of his neighbors pulling turnips from a field so steep that he could barely stand on it. Every time he yanked out a plant, a little wave of soil rolled downhill past his feet.

SOMETIME IN THE 1970S, "Sahel" became a watchword for famine, poverty, and environmental waste. Technically, though, the name refers to the semiarid zone between the Sahara desert and the wet forests of central Africa. Until the 1950s the Sahel was thinly settled. But when a population boom began, people started farming the region more intensively. Problems were masked for a long time by an unusual period of high rainfall. But then came drought. The worst effects came in two waves—one in the early 1970s and a second, even more serious, in the early 1980s—and stretched from Mauritania on the Atlantic to Chad, halfway across Africa. More than 100,000 men, women, and children died in the ensuing famine, probably many more.

"If people had the means to leave, they left," says Mathieu Ouédraogo, a development specialist in Burkina Faso, a landlocked nation in the heart of the Sahel. "The only people who stayed here had nothing—not enough to leave."

Scientists still dispute why the Sahel transformed itself from a savanna into a badland. Suggested causes include random changes in sea-surface temperatures, air pollution that causes clouds to form inopportunely, removal of surface vegetation by farmers moving into the desert periphery—and, of course, global warming. Whatever the cause, the consequences are obvious: Hammered by hot days

A toxic white crust runs through irrigated fields in Grand Valley, Colorado: Moisture evaporating from the soil has drawn underground salt to the surface. To keep the salt from damaging the roots of their crops, farmers must add even more water.

and harsh winds, much of the soil turns into a stone-hard mass that plant roots and rainwater cannot penetrate. A Sahelian farmer once let me hack at his millet field with a pick. It was like trying to chop up asphalt.

When the drought struck, international aid groups descended on the Sahel by the score. (Ouédraogo, for instance, directed a project for Oxfam in the part of Burkina where he had been born and raised.) Many are still there now; half the signs in Niamey, capital of neighboring Niger, seem to be announcing a new program from the United Nations, a Western government, or a private charity. Among the biggest is the Keita project, established 24 years ago by the Italian government in mountainous central Niger. Its goal: bringing 1,876 square miles of broken, barren earth—now home to 230,000 souls—to ecological, economic, and social health. Italian agronomists and engineers cut 194 miles of road through the slopes, dug 684 wells in the stony land, constructed 52 village schools, and planted more than 18 million trees. With bulldozers and tractors, workers carved 41 dams into the hills to catch water from the summer rains. To cut holes in the ground for tree planting, an Italian named Venanzio Vallerani designed and built two huge plows—"monstrous" was the descriptor used by Amadou Haya, an environmental specialist with the project. Workers hauled the machines to the bare hills, filled their bellies full of fuel, and set them to work. Roaring across the plateaus for months on end, they cut as many as 1,500 holes an hour.

Early one morning Haya took us to a rainwater-storage dam outside the village of Koutki, about 20 minutes down a rutted dirt road from Keita project headquarters. The water, spreading oasis-like over several acres, was almost absurdly calm; birds were noisily in evidence. Women waded into the water to fill plastic jerry cans, their brilliant robes floating around their ankles. Twenty-five years ago Koutki was a bit player in the tragedy of the Sahel. Most of its animals had died or been eaten. There was not a scrap of green in sight. No birds sang. People survived

We have degraded an area of land the size of the United States and Canada combined.

on mouthfuls of rice from foreign charities. On the road to Koutki we met a former soldier who had helped distribute the aid. His face froze when he spoke about the starving children he had seen. Today there are barricades of trees to stop the winds, low terraces for planting trees, and lines of stone to interrupt the eroding flow of rainwater. The soil around the dam is still dry and poor, but one can imagine people making a living from it.

Budgeted at more than $100 million, however, the Keita project is expensive—Niger's per capita income, low even for the Sahel, is less than $800 a year. Keita boosters can argue that it costs two-thirds of an F-22 fighter jet. But the Sahel is vast—Niger alone is a thousand miles across. Reclaiming even part of this area would require huge sums if done by Keita methods. In consequence, critics have argued that soil-restoration efforts in the drylands are almost pointless: best turn to more promising ground.

Wrong, says Chris Reij, a geographer at VU (Free University) Amsterdam. Having worked with Sahelian colleagues for more than 30 years, Reij has come to believe that farmers themselves have beaten back the desert in vast areas. "It is one of Africa's greatest ecological success stories," he says, "a model for the rest of the world." But almost nobody outside has paid attention; if soil is MEGO, soil in Africa is MEGO squared.

In Burkina, Mathieu Ouédraogo was there from the beginning. He assembled the farmers in his area, and by 1981 they were experimenting together with techniques to restore the soil, some of them traditions that Ouédraogo had heard about in school. One of them was *cordons pierreux:* long lines of stones, each perhaps the size of a big fist. Snagged by the cordon, rains washing over crusty Sahelian soil pause long enough to percolate. Suspended silt falls to the bottom, along with seeds that sprout in this slightly richer environment. The line of stones becomes a line of plants that slows the water further. More seeds sprout at the upstream edge. Grasses are replaced by shrubs and trees, which enrich the soil with falling leaves. In a few years a simple line of rocks can restore an entire field.

For a time Ouédraogo worked with a farmer named Yacouba Sawadogo. Innovative and independent-minded, he wanted to stay on his farm with his three wives and 31 children. "From my grandfather's grandfather's grandfather, we were always here," he says. Sawadogo, too, laid cordons pierreux across his fields. But during the dry season he also hacked thousands of foot-deep holes in his fields—*zaï,* as they are called, a technique he had heard about from his parents. Sawadogo salted each pit with manure, which attracted termites. The termites digested the organic matter, making its nutrients more readily available to plants. Equally important, the insects dug channels in the soil. When the rains came, water trickled through the termite holes into the ground. In each hole Sawadogo planted trees. "Without trees, no soil," he says. The trees thrived in the looser, wetter soil in each zaï. Stone by stone, hole by hole, Sawadogo turned 50 acres of wasteland into the biggest private forest for hundreds of miles.

Using the zaï, Sawadogo says, he became almost "the only farmer from here to Mali who had any millet." His neighbors, not surprisingly, noticed. Sawadogo formed a zaï association, which promotes the technique at an annual show in his family compound. Hundreds of farmers have come to watch him hack out zaï with his hoe. The new techniques, simple and inexpensive, spread far and wide. The more people worked the soil, the richer it became. Higher rainfall was responsible for part of the regrowth (though it never returned to the level of the 1950s). But mostly it was due to millions of men and women intensively working the land.

Last year Reij made a thousand-mile trek across Mali and then into southwestern Burkina with Edwige Botoni, a researcher at the Permanent Interstate Committee for Drought Control in the Sahel, a regional policy center in Burkina. They saw "millions of hectares" of restored land, Botoni says, "more than I had believed possible." Next door in Niger is an even greater success, says Mahamane Larwanou, a forester at Abdou Moumouni Dioffo University in Niamey. Almost without any support or direction

Trailing puffs of silt, a cultivator prepares a Washington State field for planting. The Palouse Hills are “wheat country,” says soil scientist John Reganold. Here large-scale intensive agriculture rules—and productivity depends on chemical pesticides and fertilizers.

from governments or aid agencies, local farmers have used picks and shovels to regenerate more than 19,000 square miles of land.

Economics as much as ecology is key to Niger's success, Larwanou says. In the 1990s the Niger government, which distributed land in orthodox totalitarian fashion, began to let villagers have more control over their plots. People came to believe that they could invest in their land with little risk that it would be arbitrarily taken away. Combined with techniques like the zaï and cordons pierreux, land reform has helped villagers become less vulnerable to climate fluctuations. Even if there were a severe drought, Larwanou says, Nigeriens "would not feel the impact the way they did in 1973 or 1984."

Burkina Faso has not recovered as much as Niger. Sawadogo's story suggests one reason why. While villagers in Niger have gained control over their land, smallholders in Burkina still lease it, often for no charge, from landowners who can revoke the lease at the end of any term. To provide income for Burkina's cities, the central government let them annex and then sell land on their peripheries—without fairly compensating the people who already lived there. Sawadogo's village is a few miles away from Ouahigouya, a city of 64,000 people. Among the richest properties in Ouahigouya's newly annexed land was Sawadogo's forest, a storehouse of timber. Surveyors went through the property, slicing it into tenth-of-an-acre parcels marked by heavy stakes. As the original owner, Sawadogo will be allotted one parcel; his older children will also each receive land. Everything else will be sold off, probably next year. He watched helplessly as city officials pounded a stake in his bedroom floor. Another lot line cut through his father's grave. Today Yacouba Sawadogo is trying to find enough money to buy the forest in which he has invested his life. Because he has made the land so valuable, the price is impossibly high: about $20,000. Meanwhile, he tends his trees. "I have enough courage to hope," he says.

WIM SOMBROEK LEARNED about soil as a child, during the *hongerwinter*—the Dutch wartime famine of 1944-45, in which 20,000 or more people died. His family survived on the harvest from a minute plot of *plaggen* soil: land enriched by generations of careful fertilization. If his ancestors hadn't taken care of their land, he once told me, the whole family might have died.

In the 1950s, early in his career as a soil

In the Amazon (above), excavations reveal fertile *terra preta* deposits, which archaeologist Eduardo Góes Neves (left, in blue) believes ancient people created by mixing charcoal from their fires with food and other wastes. Their low-tech strategy could offer farmers in the developing world a low-cost way to improve poor soils.

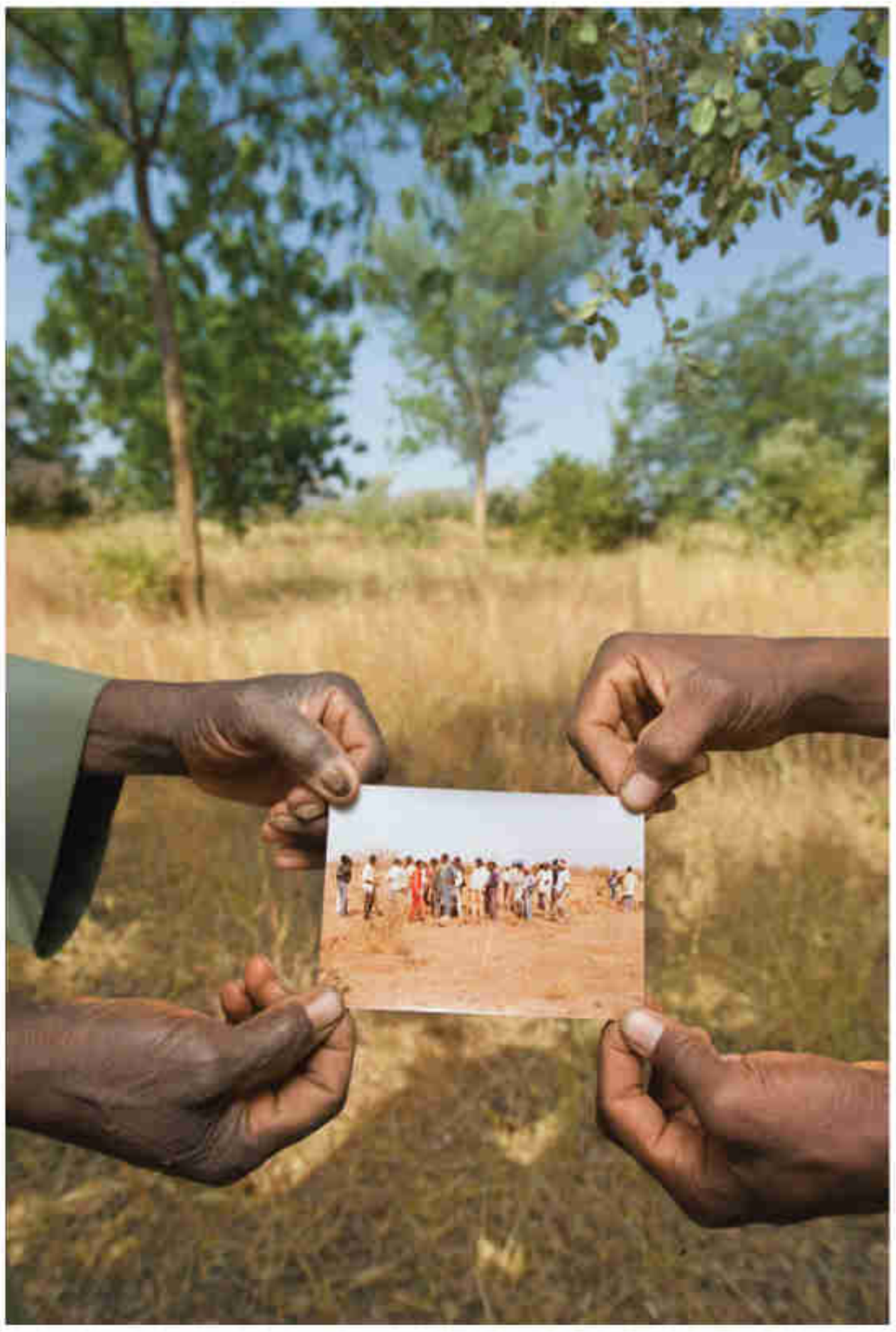
scientist, Sombroek journeyed to Amazonia. To his amazement, he found pockets of rich, fertile soil. Every Ecology 101 student knows that Amazonian rain forest soils are fragile and impoverished. If farmers cut down the canopy of trees overhead to clear cropland, they expose the earth to the pummeling rain and sun, which quickly wash away its small store of minerals and nutrients and bake what remains into something resembling brick—a "wet desert," as these ruined areas are sometimes called. The certainty of wrecking the land, environmentalists argue, makes large-scale agriculture impossible in the tropics. Nevertheless, scattered along the Amazon River, Sombroek discovered big patches of *terra preta do índio* (black Indian earth). As lush and dark as the plaggen of his childhood, it formed a rich base for agriculture in a land where it was not supposed to exist. Naturally, Sombroek paid attention. His 1966 book, *Amazon Soils*, included the first sustained study of terra preta.

Later Sombroek worked across the globe, eventually becoming director of ISRIC and secretary general of the International Society of Soil Science (now International Union of Soil Sciences), positions he used to convene the first ever world survey of human-induced soil degradation. All the while he never forgot the strange black earth in Brazil. Most restoration programs, like those in China and the Sahel, try to restore degraded soil to its previous condition. But in much of the tropics, its natural state is marginal—one reason so many tropical countries are poor. Sombroek came to believe that terra preta might show scientists how to make land richer than it ever had been, and thus help the world's most impoverished nations feed themselves.

Sombroek will never see his dream fulfilled—he died in 2003. But he helped to assemble a multinational research collaboration to investigate the origin and function of terra preta. Among its members is Eduardo Góes Neves, a University of São Paulo archaeologist whom I

Tiny earthworks stipple bare slopes in China's Zizhou County, each intended to cradle a single sapling. Government-mandated reforestation programs are intended to halt erosion, but many earlier efforts here in the Loess Plateau failed when newly planted trees died.

By 2030, 8.3 billion people will walk the Earth, and farmers will have to grow 30 percent more grain.



visited not long ago at a papaya plantation about a thousand miles up the Amazon, across the river from the city of Manaus. Beneath the trees was the unmistakable spoor of archaeological investigation: precisely squared off trenches, some of them seven feet deep. In the pits the terra preta, blacker than the blackest coffee, extended from the surface down as much as six feet. Top to bottom, the soil was filled with broken pre-Columbian pottery. It was as if the river's first inhabitants had thrown a huge, rowdy frat party, smashing every plate in sight, then buried the evidence.

Terra preta is found only where people lived, which means that it is an artificial, human-made soil, dating from before the arrival of Europeans. Neves and his colleagues have been trying to find out how the Amazon's peoples made it, and why. The soil is rich in vital minerals such as phosphorus, calcium, zinc, and manganese, which are scarce in most tropical soils. But its most striking ingredient is charcoal—vast quantities of it, the source of terra preta's color. Neves isn't sure whether Indians had stirred the charcoal into the soil deliberately, if they had done it accidentally while disposing of household trash, or even if the terra preta created by charcoal initially had been used for farming. Ultimately, though, it became a resource that could sustain entire settlements; indeed, Neves said, a thousand years ago two Indian groups may have gone to war over control of this terra preta.

Unlike ordinary tropical soils, terra preta remains fertile after centuries of exposure to tropical sun and rain, notes Wenceslau Teixeira, a soil scientist at Embrapa, a network of agricultural research and extension agencies in Brazil. Its remarkable resilience, he says, has been demonstrated at Embrapa's facility in Manaus, where scientists test new crop varieties in replica patches of terra preta. "For 40 years, that's where they tried out rice, corn, manioc, beans, you name it," Teixeira says. "It was all just what you're not supposed to do in the tropics—annual crops, completely exposed to sun and rain. It's as if we were trying to ruin it, and we haven't succeeded!" Teixeira is now testing terra preta with bananas and other tropical crops.

Sombroek had wondered if modern farmers might create their own terra preta—*terra preta nova,* as he dubbed it. Much as the green revolution dramatically improved the developing world's crops, terra preta could unleash what the scientific journal *Nature* has called a "black revolution" across the broad arc of impoverished soil from Southeast Asia to Africa.

Key to terra preta is charcoal, made by burning plants and refuse at low temperatures. In March a research team led by Christoph Steiner, then of the University of Bayreuth, reported that simply adding crumbled charcoal and condensed smoke to typically bad tropical soils caused an "exponential increase" in the microbial population—kick-starting the underground ecosystem that is critical to fertility. Tropical soils quickly lose microbial richness when converted to agriculture. Charcoal seems to provide habitat for microbes—making a kind of artificial soil within the soil—partly because nutrients

In a 1986 snapshot (left, foreground) Gourcy, Burkina Faso, was a deforested waste. Simple strategies like placing stones along slopes to stop runoff helped villagers regreen the landscape. With trees to help hold water, farmers like Issa Aminatou of Keita, in Niger, can grow more food and weather droughts.

Some believe that global warming can be slowed significantly by using carbon to reengineer bad soils.

bind to the charcoal rather than being washed away. Tests by a U.S.-Brazilian team in 2006 found that terra preta had a far greater number and variety of microorganisms than typical tropical soils—it was literally more alive.

A black revolution might even help combat global warming. Agriculture accounts for more than one-eighth of humankind's production of greenhouse gases. Heavily plowed soil releases carbon dioxide as it exposes once buried organic matter. Sombroek argued that creating terra preta around the world would use so much carbon-rich charcoal that it could more than offset the release of soil carbon into the atmosphere. According to William I. Woods, a geographer and soil scientist at the University of Kansas, charcoal-rich terra preta has 10 or 20 times more carbon than typical tropical soils, and the carbon can be buried much deeper down. Rough calculations show that "the amount of carbon we can put into the soil is staggering," Woods says. Last year Cornell University soil scientist Johannes Lehmann estimated in *Nature* that simply converting residues from commercial forestry, fallow farm fields, and annual crops to charcoal could compensate for about a third of U.S. fossil-fuel emissions. Indeed, Lehmann and two colleagues have argued that humankind's use of fossil fuels worldwide could be wholly offset by storing carbon in terra preta nova.

Such hopes will not be easy to fulfill. Identifying the organisms associated with terra preta will be difficult. And nobody knows for sure how much carbon can be stored in soil—some studies suggest there may be a finite limit. But Woods believes that the odds of a payoff are good. "The world is going to hear a lot more about terra preta," he says.

WALKING THE ROADS ON THE FARM hosting Wisconsin Farm Technology Days, it was easy for me to figure out what had worried Jethro Tull. Not Jethro Tull the 1970s rock band—Jethro Tull the agricultural reformer of the 18th century. Under my feet the prairie soil had been squashed by tractors and harvesters into a peculiar surface that felt like the poured-rubber flooring used around swimming pools. It was a modern version of a phenomenon noted by Tull: When farmers always plow in the same path, the ground becomes "trodden as hard as the Highway by the Cattle that draw the Harrows."

Tull knew the solution: Don't keep plowing in the same path. In fact, farmers are increasingly not using plows at all—a system called no-till farming. But their other machines continue to grow in size and weight. In Europe, soil compaction is thought to affect almost 130,000 square miles of farmland, and one expert suggests that the reduced harvests from compaction cost midwestern farmers in the U.S. $100 million in lost revenue every year.

The ultimate reason that compaction continues to afflict rich nations is the same reason that other forms of soil degradation afflict poor ones: Political and economic institutions are not set up to pay attention to soils. The Chinese officials who are rewarded for getting trees planted without concern about their survival are little different from the farmers in the Midwest who continue to use huge harvesters because they can't afford the labor to run several smaller machines.

Next to the compacted road on the Wisconsin farm was a demonstration of horse-drawn plowing. The earth curling up from the moldboard was dark, moist, refulgent—perfect midwestern topsoil. Photographer Jim Richardson got on his belly to capture it. He asked me to hunker down and hold a light. Soon we drew a small, puzzled crowd. Someone explained that we were looking at the soil. "What are they doing that for?" one woman asked loudly. In her voice I could hear the thought: MEGO.

When I told this story over the phone to David Montgomery, the University of Washington geologist, I could almost hear him shaking his head. "With eight billion people, we're going to *have* to start getting interested in soil," he said. "We're simply not going to be able to keep treating it like dirt." □

Dig In Learn how stones, no-till farming, and composting toilets can protect soil at **ngm.com.**

After losing a foot of soil from parts of their Iowa corn farm, the Reed family changed the way they prepare fields for planting, to limit erosion. Cletus Reed, 80, hopes his grandson, Sam, will work these acres someday. "The land takes care of us as we care for it," he says.

Dirt Poor

Haiti has lost its soil—
and the means to feed itself.

As a substitute for unaffordable imported food, some desperate Haitians turn to cakes made of clay, salt, and shortening—a traditional dietary supplement for pregnant women. Yolen Jeunky collects a batch to sell in Port-au-Prince.

ARIANA CUBILLOS, AP IMAGES

BY JOEL K. BOURNE, JR. NATIONAL GEOGRAPHIC CONTRIBUTING WRITER

Rice makes up 20 percent of the typical Haitian's diet, and that percentage is growing. In 1981 Haiti imported 18,000 tons of rice. Now the country imports close to 400,000 tons annually. Less than a quarter is homegrown.

"Tè a fatige," said 70 percent of Haitian farmers in a recent survey when asked about the major agricultural problems they faced. "The earth is tired."

And no wonder. Virtually since 1492, when Columbus first set foot on the heavily forested island of Hispaniola, the mountainous nation has shed both topsoil and blood—first to the Spanish, who planted sugar, then to the French, who cut down the forests to make room for lucrative coffee, indigo, and tobacco. Even after Haitian slaves revolted in 1804 and threw off the yoke of colonialism, France collected 93 million francs in restitution from its former colony—much of it in timber. Soon after independence, upper-class speculators and planters pushed the peasant classes out of the few fertile valleys and into the steep, forested rural areas, where their shrinking, intensively cultivated plots of maize, beans, and cassava have combined with a growing fuelwood-charcoal industry to exacerbate deforestation and soil loss. Today less than 4 percent of Haiti's forests remain, and in many places the soil has eroded right down to the bedrock. From 1991 to 2002, food production per capita actually fell 30 percent.

So what do you do if you live in the poorest nation in the Western Hemisphere, and the price of the primary carbohydrate—"Miami rice" from the U.S.—doubles? Mostly, you go hungry and watch your children do the same.

But there is more at stake than simply the ability of Haitian soil to feed a starving nation. Food-importing nations around the world also are suffering as the prices of staples skyrocket, raising critical questions about the goals of agricultural-assistance programs that over the past few decades have focused more on reducing tariffs and growing crops for export than on helping poor nations feed themselves.

That's as it should be, officials say. "Food self-sufficiency is not necessarily the goal," says Beth Cypser, deputy director of the U.S. Agency for International Development mission in Haiti. "Right now there is food in Haiti. It's just the price is out of reach. If it makes sense economically for them to sell mangoes and import rice, then that's what they should do."

The problem, says ecologist and activist Sasha Kramer, is that these days Haitian farmers can't sell enough mangoes to afford imported rice. To boost food production, Kramer and colleagues founded Sustainable Organic Integrated Livelihoods (SOIL), a nonprofit group that builds composting toilets in rural communities to get much needed organic matter and fertility back into fields. "With the current hunger crisis, it's very clear," says Kramer, an adjunct professor at the University of Miami. "If Haitians had more local production, they would not be so vulnerable to imported food prices."

Until then Haiti remains a poignant lesson in what soil scientists have preached for years: As a nation's soil goes, so goes the nation. □

Seen from space, Haiti's barren soils border the forests of the Dominican Republic—the Haitian side deforested in part to satisfy a rising demand for charcoal in places like Cité Soleil (below), one of the capital's growing slums. One in five Haitians is chronically malnourished.

NASA GODDARD SPACE FLIGHT CENTER (TOP); TYLER HICKS, NEW YORK TIMES/REDUX

In the wrestling rings of Bolivia, skirts fly as

CHOLITAS FIGHT BACK!

A fluttering of lacy petticoats won't ease the sting of the leg drop "Juanita the Loving One" is poised to inflict on her opponent. The spectacle of native Aymara women in traditional dress—*cholitas*—theatrically mauling each other draws crowds in El Alto, high in the hills above La Paz.

Ardent fans strain to touch Juanita the Loving One as she bursts from behind the curtain and strides toward the ring. The fighting cholitas see themselves as symbols of strength: Their opponents include bigotry and sexism. "My goal," says one fighter, "is to lift up indigenous women, who have been treated with contempt."

By Alma Guillermoprieto
Photographs by Ivan Kashinsky

At the largest public gymnasium in El Alto, Bolivia, daylight is fading from the windows, and hundreds of people along the bleachers are growing impatient. They have been sitting for more than two hours now, jeering and whistling and yelling encouragement at the succession of *artistas* who have faced off in the center of the gym to match wits and perform dazzling feats of strength and skill. But it is growing late, and over the blaring disco music, foot-stomping and impatient whistles can be heard in crescendo: "Bring them on!" The music grows louder, the whistling too; there is a sense that rebellion

may be about to erupt, but at last the house-lights flash and dim, and the music shifts to the *chunka-chunka* beat of a modern Bolivian *huayño.* An announcer emotes into the microphone, the curtains leading to the locker rooms part, and "Amorous Yolanda" and "Evil Claudina," this evening's stars, make their longed-for appearance to ecstatic applause.

Like many of the women of Aymara descent in the audience, Yolanda and Claudina are dressed to the nines in the traditional fashion of the Andean highlands: shiny skirts over layers of petticoats, embroidered shawls pinned with filigreed jewelry, bowler hats. Their costumes glisten in the spotlights while they make a regal progress around the bleachers, greeting their public with the genteel smiles of princesses, twirling and waving gracefully until the music stops. That's the sign for the two women to swing themselves deftly onto the wrestling ring that has been the focus of this afternoon's activity. Swiftly they remove their hats, unpin their shawls, and…*whap, whap, whap!* Claudina belts Yolanda one, Yolanda slaps Claudina, Claudina tries to escape, but Yolanda grabs Claudina by her pigtails and spins her around, and *WHAM!* Claudina whirls through the air, petticoats and braids flying, and lands flat on her back on the mat, gasping like a fish. The audience goes nuts.

Welcome to the delirious world of Bolivian wrestling. In the cold, treeless, comfortless city of El Alto ("high point"), 13,000 feet above sea level, there are one million people, most of whom fled here over the past three decades to escape the countryside's pervasive misery. The lucky ones find steady jobs down in the capital city of La Paz, which El Alto overlooks. Many sell clothes, onions, pirated DVDs, Barbie dolls, car parts, small desiccated mammals for magic rituals. The poorest *alteños* employ themselves as beasts of burden. All of them battle hopeless traffic, a constant scarcity of fuel and water, the dull fatigue of numbing labor, the odds that are stacked against them. When they're done working, they need to play, and when they want to play, one never knows what they will come up with. Lately, they've come up with the extraordinary spectacle of the *cholitas luchadoras*—fighting cholitas—which has given new life to Bolivians' own version of Mexican *lucha libre,* a free-form spectacle somewhere between a passion play, a wrestling match, and bedlam.

"Watch out!" the entire audience shrieks.

Alma Guillermoprieto wrote about Bolivia in the July issue. Ivan Kashinsky lives in Quito, Ecuador. This is his first assignment for National Geographic.

Hundreds pack a gymnasium in El Alto each Sunday to see the Titans of the Ring clash. Ticket sales for the originally all-male *lucha libre* program—$1.50 for locals, and a few dollars more for curious foreigners (who get perks like front-row seats and a guide)—boomed after organizer Juan Mamani added women wrestlers to the lineup in 2001.

Yolanda has been celebrating her victory, but Claudina, as proof of her evil nature, is about to lunge at her from behind. Yolanda spins too late; Claudina knocks her flat and clambers like a crazy person onto the ropes. "I'm the prettiest!" she yells at the audience. "You're all ugly! I'm your daddy! I'm the one the gringos have come to see!" Indeed three rows of ringside seats are filled with foreigners, all pop-eyed, but they're actually irrelevant. It's their fellow Bolivians the cholitas are performing for.

Claudina, who is officially a *ruda*, or baddie, has taken a swig of soda pop and is spraying

Seventeen-year-old "Alicia Flores" topples under the blow of a chair, with blood—or is it stage blood?—streaming down her forehead. The women wrestlers, whose ages range from teens to late 30s, train long hours to prepare for the very real violence of the matches, and insist they don't fake their wounds.

the public with it at the precise moment that Yolanda, a *técnica,* or goodie, pounces on her and drags her up to the bleachers, sending the spectators there scattering in blissful, screaming alarm. Yolanda wins! No, Claudina wins! No, Yolanda! But wait! The audience screams in warning again because a new menace has silently made his entrance: "Black Abyss"—or maybe it's "Satanic Death" or the "White Skeleton"; it's hard to keep track—has leaped into the fray and has Yolanda in a ferocious leg lock. The situation looks hopeless, but no, here comes the "Last Dragon," out of nowhere, and he's carrying a chair! And he's whomping Black Abyss, or maybe the Skeleton, or maybe Yolanda, on the head with it! Even Claudina seems to have lost track of who's who: She's taking a flying leap at her own ally, the loathsome "Picudo." "He is destroyed forever!" the announcer yells frenetically.

Or almost forever: In lucha libre, no defeat is ever final.

"What I want to make absolutely clear," says Juan Mamani, who fights as a *rudo* under the lucha name of "El Gitano" and who runs the show, "is that it was me who came up with the idea of the cholitas." Mamani is a tall,

Her slight form bulked up by the many layers of her *pollera* skirt, "Amorous Yolanda" humbles burly "Craquen." Female fans relish victories over male wrestlers by tough cholitas—scripted though they are. "I am a loving person outside the ring," Yolanda says. "But once in the ring, Amorous Yolanda becomes 'Hateful Yolanda.'"

In a makeshift ring in a scruffy backyard, "Carmen Rosa" (center, in yellow) squares off with Amorous Yolanda in a practice match. Carmen Rosa is the leader of the upstart Goddesses of the Ring wrestling group—fighting cholitas who split off from the Titans of the Ring after disputes with Titans manager Juan Mamani.

"It's a distraction. The cholitas fight here, and we laugh and forget our troubles for three or four hours. At home, we're sad."

Esperanza Cancina

angular man whom it would be kind to call unfriendly. He cuts phone conversations short by hanging up, does not show up for appointments he has been cornered into making, and tries to charge for interviews. His cholitas are terrified of him. "Don't tell him you called me; don't tell him you have my phone number!" one of them begged.

I hunted him down near the El Alto gym, and after an unpromising start—he kept trying to duck past me—I said the magic words "Mexico" and "Blue Demon." The face of Juan Mamani, the ogre, was suddenly wreathed in smiles. "My greatest passion is lucha libre," he

said. "And for us, Mexico is the example. Blue Demon is for me *lo mas grandioso.*"

Mamani's wrestlers all hold daytime jobs, and he makes a living from a small electrical-repair shop. But he has invested a good part of his life's earnings in a huge wrestling ring at home, where his group trains. He pays his wrestlers between $20 and $30 a match and probably doesn't clear vastly greater amounts himself. "Here in Bolivia it's impossible to make a living from this great passion of mine," Mamani said. His dream was to create a Bolivian school of wrestling heroes to equal the feats of the great Mexican lucha legends; their daring leaps and backflips, their unique costumes and regal bearing. Had I seen Blue Demon fight? Really? He shook my hand as I left.

About seven years ago, when he was fretting about the diminishing audience for the weekly lucha libre spectacle at the El Alto gym, Mamani had the inspired idea to teach women to wrestle and put them in the ring in cholita clothes. "Martha la Alteña," an outgoing luchadora, not remarkably muscular but very strong, was among the 60 or so young women who answered Mamani's open audition call. Like several of the eight or so who ended up staying, she comes from a wrestling background. "My father was one of the original Mummies," she said proudly, referring to one of the best loved, or most dreaded, of Bolivian lucha's creatures.

Amorous Yolanda was also inspired by her *luchador* father, and even though her parents separated on unfriendly terms when she was an infant, she used to sneak into El Coliseo in downtown La Paz—long since gone—to watch him perform. "But a lot of times men don't believe in women," she told me. "Once I heard my father say that he wished he'd had a son instead of me, so he could follow in his footsteps as a luchador." When she heard about Mamani's casting call, Yolanda, then still called Veraluz Cortés, raced to audition, leading to a temporary rift with her father. Whether her lucha stardom also contributed to the breakup of her marriage is not clear.

Outside the ring, Martha la Alteña generally wears what is called the señorita style of dress—blue jeans and sweaters—and part of the glamour of her cholita costume is provided by turquoise-blue contact lenses. Yolanda, on the other hand, who is thin and very intense, wears a bowler hat and petticoats and skirts, even when she is knitting sweaters at her day job, and considers herself an authentic cholita.

"Sometimes my daughters ask why I insist on doing this," she said. "It's dangerous; we have many injuries, and my daughters


Jenny Mamani Herrera
SECRETARIA EJECUTIVA
Rey Mysterio
BATISTA
REY MYSTERIO
JEFF HARDY
Matt Hardy
RAW

In the room that she and her daughters share, Yenny Wilma Maraz Herrera—who wrestles as "Martha la Alteña"—prepares her fighting finery on Sunday morning. Cholitas make $20 to $30 a match wrestling for Titans of the Ring. The money supplements Maraz Herrera's income from making and selling traditional clothes and handicrafts.

Darkness falls over La Paz as Amorous Yolanda—Veraluz Cortés in her daily life—climbs a hill near her home. Unlike some fighting cholitas, she proudly wears traditional dress outside the ring. Daughter of a lucha libre wrestler, she lives for the matches: "We fighters carry within us a kind of fire that nothing can quench."

"I heard my father say that he wished he'd had a son instead of me, so he could follow in his footsteps as a luchador."

Amorous Yolanda

complain that wrestling does not bring any money into the household. But I need to improve every day. Not for myself, for Veraluz, but for the triumph of Yolanda, an artist who owes herself to her public."

Esperanza Cancina, 48, who sells used clothing for a living, has installed her large family and her ample self, in all her petticoats and skirts, in the choice ringside spot behind the announcer's chair, at a safe angle from the popcorn and chicken bones and empty plastic bottles the audience likes to pelt the rudos with. Ringside seats cost about $1.50 each,

which is hardly cheap, but Señora Cancina comes faithfully to the show every other Sunday. "It's a distraction," she explains. "The cholitas fight here, and we laugh and forget our troubles for three or four hours. At home, we're sad."

Around us, the youngest members of the audience, including her grandchildren, are skittering around the edges of the ring in an adrenaline frenzy, trying out lucha leaps and swarming after a wrestler who has just been defeated, trying to hug him, touch his costume. The music is booming, and it's hard to conduct a conversation, but Señora Cancina is amiable and cooperative. She had 12 children, she says, but after a pause adds that six died. How? Her face takes on a distressing blankness. "Scarlet fever, diarrhea, those things…" she murmurs, and has to repeat the answer over the noise. Would she have wanted to be a luchadora too? Definitely, she says. "Our husbands make fools of us, but if we were wrestlers we could express our fury."

Over on the long side of the bleachers, in the prime chicken-bone-throwing area, Rubén Copa, a shoemaker from La Paz with an easy, friendly smile, is waiting impatiently for the afternoon's final match—one in which the "Mummy Ramses II" will take on cholitas yet to be announced. "Bolivian wrestlers aren't half bad, you know," he says with a touch of pride. Not even the women? He huffs and waves his hands in protest. "There's none of that anymore! Every kind of work is for everyone now." I want to know if it's true that men come to the lucha libre just to see the cholitas' (very modest) underpants. For a moment he looks offended, but then he smiles again. "Not at all!" he says. "I come to see them wrestle! You'll see for yourself how good they are."

And indeed a few minutes later the Mummy Ramses II is staggering around invincibly in a red-stained jumpsuit and a fright wig, dragging one cholita behind him while another one looks for something to set him on fire with, and the kids are screaming in delicious terror, and Señora Cancina is yelling things at the Mummy that cannot be printed in this magazine, grinning broadly as she does so. The Mummy is slamming his victim against the wall, and it looks tough for the cholitas, as the announcer warns us, in this *definitivo y final combate*—it looks very, very tough. But something tells me that you can't keep a cholita down.

Here comes Martha, flying through the air! □

Going to the Mat Hear a match and see wrestlers strike their poses in a multimedia event at **ngm.com.**

LOST TRIBES OF THE GREEN SAHARA

How a dinosaur hunter uncovered the Sahara's strangest Stone Age graveyard

Archaeologists unearthed the 6,000-year-old bones of a woman buried at a site called Gobero in northern Niger. Some 200 graves found near a vanished lake hint at life in a once fertile land.

BY PETER GWIN
NATIONAL GEOGRAPHIC STAFF

PHOTOGRAPHS BY MIKE HETTWER

On October 13, 2000, a small team of paleontologists led by Paul Sereno of the University of Chicago clambered out of three battered Land Rovers, filled their water bottles, and scattered on foot across the toffee-colored sands of the Ténéré desert in northern Niger. The Ténéré, on the southern flank of the Sahara, easily ranks among the most desolate landscapes on Earth. The Tuareg, turbaned nomads who for centuries have ruled this barren realm, refer to it as a "desert within a desert"—a California-size ocean of sand and rock, where a single massive dune might stretch a hundred miles, and the combination of 120-degree heat and inexorable winds can wick the water from a human body in less than a day. The harsh conditions, combined with intermittent conflict between the Tuareg and the Niger government, have kept the region largely unexplored.

Sereno, a National Geographic Society explorer-in-residence and one of the world's most prolific dinosaur hunters, had led his first expedition into the Ténéré five years earlier, after negotiating agreements with both the leader of a Tuareg rebel force and the Niger Ministry of Defense, allowing him safe passage to explore its fossil-rich deposits. That initial foray was followed by others, and each time his team emerged from the desert with the remains of exotic species, including *Nigersaurus*, a 500-toothed plant-eating dinosaur, and *Sarcosuchus*, an extinct crocodilian the size of a city bus. The 2000 expedition, however, was his most ambitious—three months scouring a 300-mile arc of the Ténéré, ending near Agadez, a medieval caravan town on the western lip of the desert. Already, his team members had excavated 20 tons of dinosaur bones and other prehistoric animals. But six weeks of hard labor in this brutal environment had worn them down. Most had mild cases of dysentery; several had lost so much weight they had to hitch up their trousers as they trudged over the soft sand; and everyone's nerves had been on edge since an encounter with armed bandits.

Mike Hettwer, a photographer accompanying the team, headed off by himself toward a trio of small dunes. He crested the first slope and stared in amazement. The dunes were spilling over with bones. He took a few shots with his digital camera and hurried back to the Land Rovers.

"I found some bones," Hettwer said, when the team had regrouped. "But they're not dinosaurs. They're human."

Heat, thirst, and, for the moment, dinosaurs were forgotten as the team members followed Hettwer back to the three dunes and began to gingerly survey their slopes. In just a few minutes they had counted dozens of human skeletons. Parts of skullcaps pushed up through the sand like upturned china bowls; jawbones clenched nearly full sets of teeth; a tiny hand, perhaps a child's, appeared to have floated up

Paleontologist Paul Sereno (right) has spent years excavating dinosaur bones, but to probe Gobero's burials, he joined forces with archaeologists Elena Garcea (center) and Boubé Adamou (left).

through the sand with all its finger bones intact. "It was as if the desert winds were pulling them from their final resting places," said Hettwer. Insinuated among the human bones was a profusion of clay potsherds, beads, and stone tools—finely worked arrowheads and axheads and well-worn grindstones. There were also hundreds of animal bones. In addition to antelope and giraffe, Sereno quickly recognized the remains of water-adapted creatures like crocodiles and hippos, then turtles, fish, and clams. "Everywhere you turned, there were bones belonging to animals that don't live in the desert," said Sereno. "I realized we were in the Green Sahara."

For much of the past 70,000 years, the Sahara has closely resembled the desert it is today. Some 12,000 years ago, however, a wobble in the Earth's axis and other factors caused Africa's seasonal monsoons to shift slightly north, bringing new rains to an area nearly the size of the contiguous United States. Lush watersheds stretched across the Sahara, from Egypt to Mauritania, drawing animal life and eventually people.

Archaeologists have inventoried the stone tools used by these early inhabitants and the patterns inscribed on their ceramics. They have also identified thousands of their rock engravings, which depict herds of ostriches, giraffes, and elephants. Some of the images suggest that along the way the people of the Green Sahara learned to domesticate cattle. But they remain veiled in mystery. Did they arrive here from the Mediterranean coast, central African jungles, or Nile Valley? Were they nomads, or did they stake out territories and build settlements? Did they trade with each other and intermarry, or did they wage war, or both? As the monsoons began to recede, how did they cope with a drying landscape? The only part of the story that

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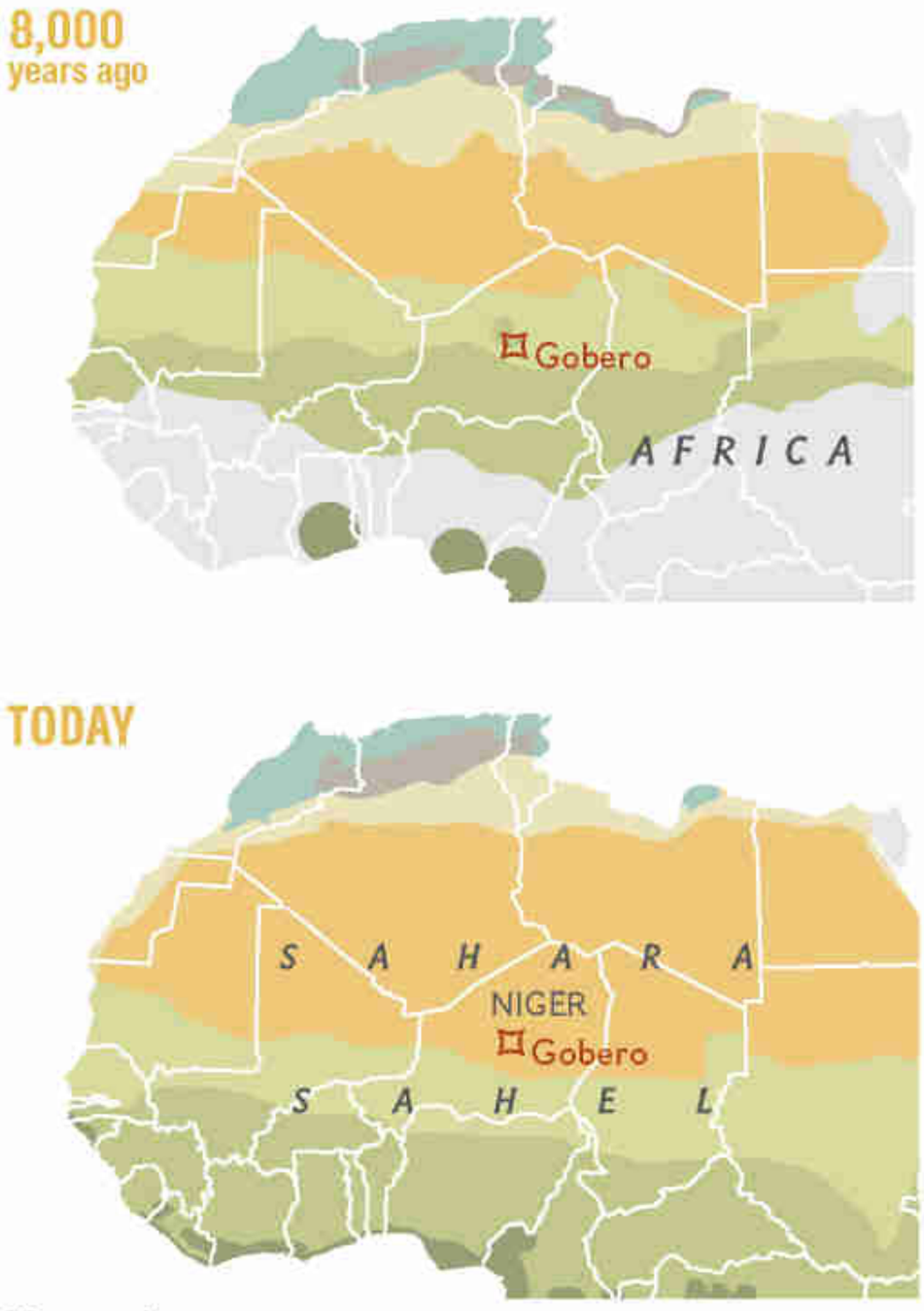
A veteran of five expeditions in the Gobi and Sahara deserts, Mike Hettwer photographed "SuperCroc" for National Geographic *in December 2001.*

Scientists long suspected that the Sahara wasn't always dry. Then, during a 1981 space shuttle mission, NASA used a synthetic aperture radar to peer through sands to the desert's underbelly, revealing a network of river courses inscribed in the bedrock during multiple wet intervals.

NASA/JPL

A GREEN MOMENT

Pollen studies show grasslands and pockets of forest periodically flourished in the Sahara. Many factors, including a wobble in the Earth's axis, helped shift seasonal rains northward.



NGM MAPS. SOURCE: INSTITUTE OF GEOGRAPHY, UNIVERSITY OF WÜRZBURG

seems clear is that by some 3,500 years ago the desert had returned. The people vanished.

Seeking answers to such questions is normally the domain of anthropologists and archaeologists—not dinosaur hunters. But Sereno had become transfixed by the discovery. "There is something soul stirring about looking into the face of an ancient human skull and knowing this is my species," he said. Whenever he could steal a moment from his paleontological work, he pored through every scholarly publication he could find on the Green Saharans, then tracked down the authors and badgered them with emails full of questions. Sometimes he would read all night before downing a cup of coffee and heading back to his lab. In 2003, during another dinosaur expedition in Niger, he took three days off to revisit the dunes and survey the site, counting at least 173 burials. To dig any deeper, however, would require more time, money, and expertise.

In the spring of 2005 Sereno contacted Elena Garcea, an archaeologist at the University of Cassino, in Italy, inviting her to accompany him on a return to the site. Garcea had spent three decades working digs along the Nile in Sudan and in the mountains of the Libyan Desert, and was well acquainted with the ancient peoples of the Sahara. But she had never heard of Paul Sereno. His claim to have found so many skeletons in one place seemed far-fetched, given that no other Neolithic cemetery contained more than a dozen or so. Some archaeologists would later be skeptical; one sniped that he was just a "moonlighting paleontologist." But Garcea was too intrigued to dismiss him as an interloper. She agreed to join him.

"I was impressed that he hadn't just ignored the burials and continued looking for dinosaurs," she told me.

They arrived at the site six months later. Clad in a salt-stained T-shirt and jeans, Sereno, vibrating with energy, powered up the first of the three dunes, identifying animal bones with nearly every stride—giraffe vertebra…hippo ulna…gazelle humerus. Garcea, a petite woman in unwrinkled chinos and a tennis hat, followed at a more measured pace, bending at the waist to scrutinize each item.

At the top, they surveyed a macabre scene. Around them lay dozens of human skeletons in various degrees of completeness, far more than Garcea had seen at all her other digs combined. Nonetheless, she seemed more interested in what looked to me like tiny gray chunks of gravel. "They're potsherds," she said, and held up one inscribed with a pointillistic pattern. She identified the markings as belonging to a people known to scholars as the Tenerian, a nomadic

For nomads in the Ténéré, one of the Sahara's driest parts, finding water amid the bleak folds of the desert is a life-or-death skill. This spring-fed oasis near the Aïr mountains is a relic of a lush watershed that once stretched some 400 miles to Lake Chad and fed Gobero's lake.

herding culture that lived during the latter part of the Green Sahara era, 6,500 to 4,500 years ago. Then she picked up another piece. She studied it for a moment, looking perplexed. Instead of little dots, this sherd was decorated with wavy lines. She picked up another like it, then another. "These are Kiffian," she said, her voice rising with excitement.

Garcea explained that the Kiffian were a fishing-based culture and lived during the earliest wet period, between 10,000 and 8,000 years ago. She held a Kiffian sherd next to a Tenerian one. "What is so amazing is that the people who made these two pots lived more than a thousand years apart."

Over the next three weeks, Sereno and Garcea—along with five American excavators, five Tuareg guides, and five soldiers from Niger's army, sent to protect the camp from bandits—made a detailed map of the site, which they dubbed Gobero, after the Tuareg name for the area. They exhumed eight burials and collected scores of artifacts from both cultures. In a dry lake bed adjacent to the dunes, they found dozens of fishhooks and harpoons carved from animal bone. Apparently the Kiffian fishermen weren't just going after small fry: Scattered near the dunes were the remains of Nile perch, a beast of a fish that can weigh nearly 300 pounds, as well as crocodile and hippo bones.

Garcea suspected that the Tenerian had made most of the stone tools. Nearly three-fourths of them were hewed from a strange green volcanic rock that bore a glasslike sheen and yielded razor-sharp edges when fractured. The abundance of green flakes on the dunes indicated that the Tenerian spent long periods of time at Gobero making and sharpening their tools. "But it's possible they lived part of the time at the place where they quarried the green rock," said Garcea. One of the Tuareg said he had seen big boulders of it in the Aïr mountains, some hundred miles to the northwest.

At dusk the heat gave way to the cool evening air, and the camp divided into three groups. The soldiers, dressed in threadbare fatigues and combat boots with no socks, gathered around their fire, speaking Hausa, Niger's dominant language. At the Tuareg fire, the guides removed their linen *chèches*, which they kept neatly wound around their faces during the day. They reclined on foam mattresses, served each other strong, sugary tea, and quietly discussed Niger's restive politics in their native Tamashek. Meanwhile, the dig team cooked couscous and freeze-dried vegetables on a propane stove, eating by the light of their headlamps. Their conversations focused on the stark differences in the burials. Some appeared to be little more than a tight bundle of bones, as if the body had been bound or squeezed into a basket or a leather bag, which had long since decomposed. These compact burials belied the fact that some of these individuals were surprisingly large—as much as six feet eight inches tall, with thick bones suggesting they had been well muscled.

By contrast, other skeletons belonged to much smaller people, about five-and-a-half feet tall. They were buried on their sides in relaxed positions, as if they had fallen asleep and drifted into death. Some of their graves contained beads, arrowheads, or animal bones. But since no potsherds were found in the burials, it wasn't clear which were Kiffian and which were Tenerian. Until the age of the bones could be determined, no one could say for sure. And what had led the Tenerian to bury their dead in the exact same spot as the Kiffian had laid theirs to rest, thousands of years earlier?

"Perhaps the Tenerian found the Kiffian burials and recognized this place as sacred," Garcea offered. "It's possible they thought these bones belonged to their own ancestors."

The search for answers could not wait long. Gobero held at least 200 burials, which would take several field seasons to excavate. But the constant desert wind was eroding the site year by year, scattering the bones down the sides of the dunes. An even more dire concern was looters.

Society Grants This research is funded in part by your National Geographic Society membership.

The bodies of a Tenerian woman (at right) and two children were buried carefully arranged in a tender embrace. Pollen in the grave indicates they were laid on a bed of flowers. How the three died remains a mystery, but scientists think they probably perished within 24 hours of each other.

KIFFIAN 10,000–8,000 YEARS AGO

FISHHOOK, 1 INCH (2.5 CENTIMETERS) LONG

Beyond a handful of fishing tools carved from animal bones, the Kiffian left few clues about how they lived at Gobero. But like an airliner's black box, their bones are revealing. A skeleton records detailed data about a person's life, including diet, diseases, injuries, and habits. Teeth are particularly rich in information. Molar wear patterns suggest that the Kiffian chewed coarse grains and that some lived into their 40s. Analysis of strontium isotopes in tooth enamel indicates that they drank from a local water source and probably didn't travel far from Gobero.

MALE KIFFIAN SKULL

HARPOON, 7 IN (18 CM) LONG

Officials in Niger have identified close to a hundred Stone Age sites in the Ténéré and report that nearly all were looted before they could be excavated. Often Tuareg traveling in camel caravans find the sites and scavenge artifacts to sell to dealers in Agadez, who in turn sell them illicitly to tourists. Though the Niger government has outlawed the sale of antiquities, only Gobero and one other site remained unlooted.

Members of the dig team suspected that a few of the soldiers were picking up artifacts as they patrolled the site's perimeter. When confronted by Sereno, they denied it. One night by the Tuareg fire, I asked one of the guides whether he thought anyone might pilfer artifacts. He shrugged. "When you are hungry and your children are hungry, what can you do?" Another confided to me that over the years he had collected a small number of artifacts during his travels in the desert. He produced a leather pouch that held an array of gemlike arrowheads and a beautiful knife chipped from the strange green stone. "These are not for sale," he said. "They are for my children. It is their history. I want them to see it before it is all gone."

SERENO FLEW HOME with the most important skeletons and artifacts and immediately began planning for the next field season. In the meantime, he carefully removed one tooth from each of four skulls and sent them to a lab for radiocarbon dating. The results pegged the age of the tightly bundled burials at roughly 9,000 years old, the heart of the Kiffian era. The smaller "sleeping" skeletons turned out to be about 6,000 years old, well within the Tenerian period. At least now the scientists knew who was who.

In the fall of 2006 they returned to Gobero, accompanied by a larger dig crew and six additional scientists. Garcea hoped to excavate some 80 burials, and the team began digging. As the skeletons began to emerge from the dunes, each presented a fresh riddle, especially the Tenerian. A male skeleton had been buried with a finger

TENERIAN 6,500–4,500 YEARS AGO

DISK KNIFE, 6 IN (15 CM) LONG

The Tenerian were more lightly built than the Kiffian, with narrower crania and taller foreheads. Unlike their predecessors, they often adorned graves with myriad artifacts, including a hippo ivory pendant (below) and tools crafted from a green volcanic rock (left) quarried about a hundred miles away in the Aïr mountains. Excavations also turned up several pieces of amazonite. The closest known source for the iridescent gem is in the Tibesti mountains, some 500 miles northeast of Gobero, raising questions: Are there closer, now forgotten sources? Did the Tenerian emigrate from the Tibesti? Or were they trading with other groups?

MALE TENERIAN SKULL

PENDANT, 4 IN (10 CM) LONG

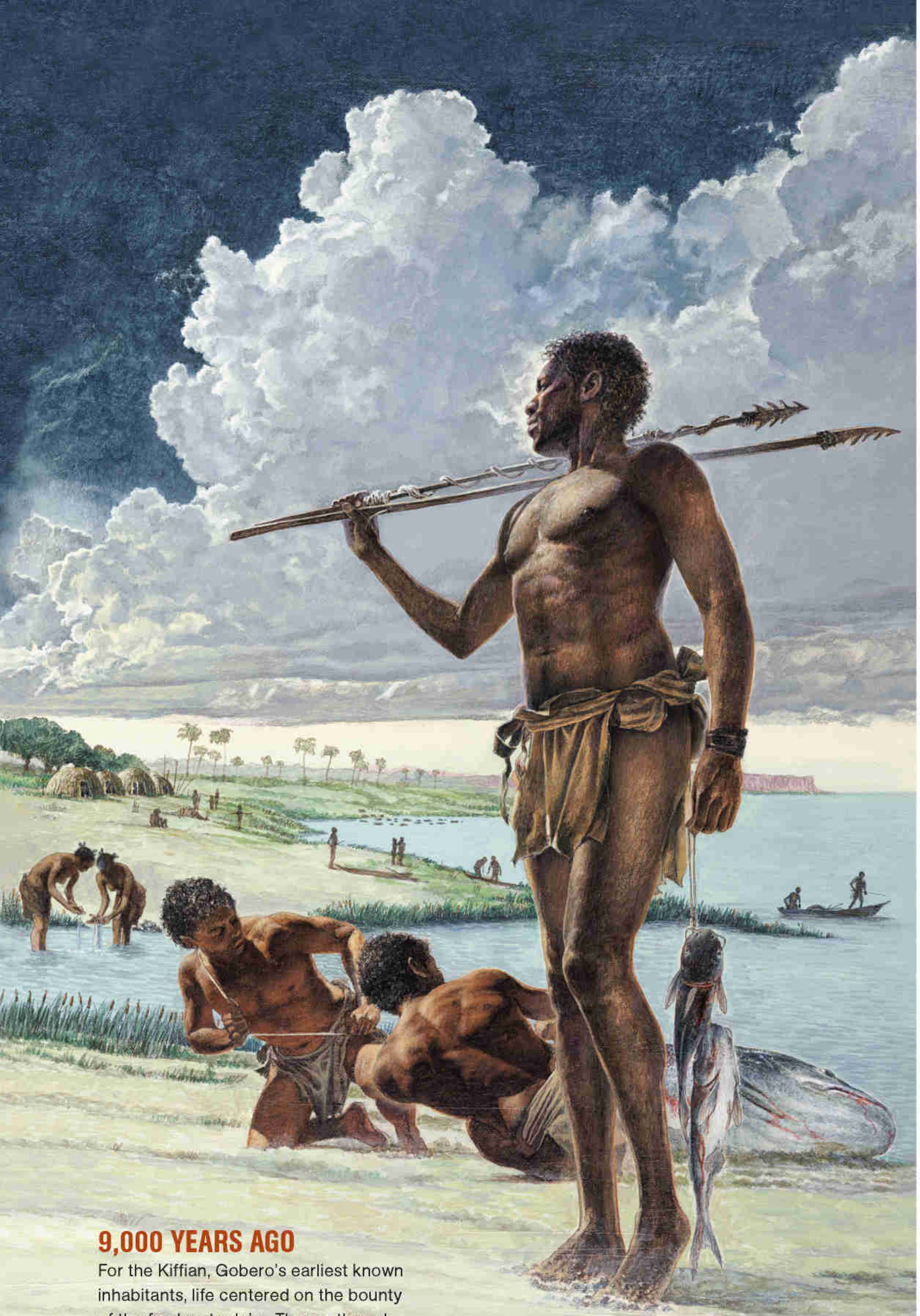
in his mouth. Another had been interred inside a frame of disarticulated human bones. Among the strangest was an adult male buried with a boar tusk and a crocodile ankle bone and his head resting on a clay pot. Parts of the skeleton appeared to have been burned, hinting that an elaborate ritual had accompanied his burial.

Garcea paid close attention to these details. In lieu of a written language, such clues are critical to understanding what she described as a culture's "software"—its traditions, value system, and beliefs about the supernatural. The very act of burial contains a message, Garcea told me as she delicately brushed dirt from another Tenerian skeleton. "By infusing the land with the remains of your people, you claim it."

Unlike the Tenerian burials, the bundles of Kiffian bones came with few artifacts to shed light on their culture. But bones and teeth alone can say a lot about the daily lives of a vanished people. Their appearance can reveal an individual's sex, age, and general health, and they hold chemical signatures that, analyzed in a lab, can reveal the kinds of food a person ate and the location of the water sources he drank from.

Even at the site, Arizona State University bioarchaeologist Chris Stojanowski could begin to piece together some clues. Judging by the bones, the Kiffian appeared to be a peaceful, hardworking people. "The lack of head and forearm injuries suggests they weren't doing much fighting," he told me. "And these guys were strong." He pointed to a long, narrow ridge running along a femur. "That's the muscle attachment," he said. "This individual had huge leg muscles, which means he was eating a lot of protein and had a strenuous lifestyle—both consistent with a fishing way of life." For contrast, he showed me the femur of a Tenerian male. The ridge was barely perceptible. "This guy had a much less strenuous lifestyle," he said, "which you might expect of a herder."

Stojanowski's assessment that the Tenerian were herders fits the prevailing view among



9,000 YEARS AGO

For the Kiffian, Gobero's earliest known inhabitants, life centered on the bounty of the freshwater lake. They gathered wild grains near the shore, harpooned Nile perch and other large fish, and probably hunted crocodiles and hippos.

6,000 YEARS AGO

After a prolonged arid interval, humans again frequented Gobero. The Tenerian may have brought cattle with them yet found that the lake attracted a rich array of game as the area grew drier, making Gobero a hunter's paradise.

ART BY KAZUHIKO SANO

Undaunted by a sandstorm, Wodaabe men promenade at a Niger festival of herding tribes. Like the Wodaabe, Gobero's last known inhabitants may have been keepers of livestock.

About the time prehistoric artists carved these life-size giraffes into an outcrop near the Aïr mountains, the Kiffian were living roughly 150 miles away in Gobero. Though their creator's identity remains a mystery, such petroglyphs record life flourishing in the Green Sahara.

scholars of life in the Sahara 6,000 years ago, when drier conditions favored herding over hunting. But if the Tenerian were herders, Sereno pointed out, where were the herds? Among the hundreds of animal bones that had turned up at the site, none belonged to goats or sheep, and only three came from a cow species. "It's not unusual for a herding culture not to slaughter their cattle, particularly in a cemetery," Garcea responded, noting that even modern pastoralists, such as Niger's Wodaabe, are loath to butcher even one animal in their herd. Perhaps, Sereno reasoned, the Tenerian at Gobero were a transitional group that had not fully adopted herding and still relied heavily on hunting and fishing.

The twilight of the Green Sahara around 4,500 years ago might have been the perfect time to be hunting at Gobero, said Carlo Giraudi, the team's geologist. As water sources dried up throughout the region, animals would have been drawn to pocket wetlands, making them easier to kill. Four middens found on the dunes and dated to around that time included hundreds of animal remains, as well as fish bones and clamshells—not usually part of a herder's diet. "The Green Sahara's climate was rapidly changing," said Giraudi, "but just before the lake dried up, the people at Gobero would have thought they were living in a golden period."

Then they were gone, leaving only bones and

a few artifacts to bear witness. On my last day at Gobero, Sereno and his colleagues began excavating a particularly poignant burial containing three skeletons. Several members of the dig team interrupted their own work to watch. Soon a few of the Tuareg abandoned their late afternoon tea and wandered over, and a couple of soldiers joined the group. Evening breezes began to sweep away the desert's intense heat. As the sand was carefully brushed away, a petite Tenerian woman came into clear relief, lying on her side. Facing her were the skeletons of two children. Their molars suggested they were five and eight years old when they died. Each child reached tiny arms toward the woman. Her fragile arm bones reached back to them. Between the skeletons lay a cluster of disarticulated finger bones, implying the deceased had been laid to rest holding hands.

Was this a mother and her children? Had a grieving father posed his family in this gesture of love before covering them with sand? The questions rippled around the graveside in English, French, Tamashek, and Hausa. The skeletons exhibited no clear signs of trauma, though four arrowheads turned up near the bones, perhaps part of a burial ritual. But if their deaths weren't violent, how did they all die at the same time? If it was a disease or a plague, who would have been left to bury the bodies in such an elaborate fashion? Maybe, someone suggested, they drowned in the lake.

Back in Arizona, Stojanowski continues to analyze the Gobero bones for clues to the Green Saharans' health and diet. Other scientists are trying to derive DNA from the teeth, which could reveal the genetic origins of the Kiffian and Tenerian—and possibly link them to descendants living today. Sereno and Garcea estimate a hundred burials remain to be excavated. But as the harsh Ténéré winds continue to erode the dunes, time is running out. "Every archaeological site has a life cycle," Garcea said. "It begins when people begin to use the place, followed by disuse, then nature takes over, and finally it is gone. Gobero is at the end of its life."

In February of 2007, as the team was making plans to return to Niger, hostilities broke out again between some of Niger's Tuareg groups and the government. By December, Human Rights Watch had reported scores of soldiers and civilians had been killed or injured in clashes and by land mines. The government declared emergency rule in the region, prohibiting foreigners from traveling to the Ténéré. Sereno and Garcea were forced to cancel the 2007 and 2008 dig seasons. Meanwhile, the wind blows across Gobero, and the desert continues to consume the last remnants of the Green Sahara. □

Desert Graves Travel with photographer Mike Hettwer as he uncovers ancient cultures at **ngm.com.**

FOLLOW UP

SOIL, PAGE 80 **Grassroots Movement** A recent NASA analysis of satellite imagery shows that nearly 50,000 square miles of turf are under cultivation in the United States, making grass the single largest irrigated crop in the country. The health of all that grass depends directly on the health of the soil in which it grows. Paul Tukey, author of *The Organic Lawn Care Manual,* suggests these ways to keep lawn soil in good shape.

■ **Follow Directions** Home application of pesticides and fertilizers often vastly exceeds that of agricultural use in pounds per acre. If you choose to use lawn chemicals, make sure to apply the correct amount. More is not better—and can be harmful to plants, pets, and people.

■ **Water Wisely** The best time to water is early morning. Watering at night may encourage mold growth or disease. Try to water once a week, rather than daily.

■ **Plant Clover** Until a pesticide company started marketing it as a weed in the 1960s, clover—which is actually a legume—was an essential part of commercial grass seed mixtures. It still should be. Nodules on clover roots store nitrogen and deliver it to the soil around the plant more efficiently than synthetic nitrogen fertilizers.

■ **Mow High** For most grass species, set mower blades to cut at a height of about three inches. Higher grass prevents weeds and helps soil retain moisture. And leave grass clippings on the lawn after mowing. They work as a natural fertilizer and will decompose within a few days.

Learn more about green living at **thegreenguide.com.**

PHOTO: MARK THIESSEN, NG PHOTOGRAPHER

Nel Cepeda

Pat Minnick included National Geographic in her financial plans.

Give An Inspiring Gift

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic. She now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

"I feel good knowing that National Geographic is doing so much to protect endangered wildlife," says Pat. "The environmental problems we face are vast, but by joining with National Geographic and their history of remarkable accomplishments, I know we can pass on a more beautiful world."

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Jerry Glover rinses wheat roots in Salina, Kansas.

ON ASSIGNMENT **He Knows All the Dirt** Land Institute scientist Jerry Glover (above) shared his knowledge of soil, advised on the logistics of digging soil cuts with backhoes, helped photographer Jim Richardson shoot an Indian grass plant's ten-foot roots (pages 94-95), and was indispensable to this issue's soil story. "We were so fortunate to be able to traipse in and benefit from the years of work that Jerry had done," Richardson says.

Samburu's elephants are used to people in cars, so Nichols (at left) shot from this one, with assistant Nathan Williamson and guide Daniel Lentipo.

ON ASSIGNMENT

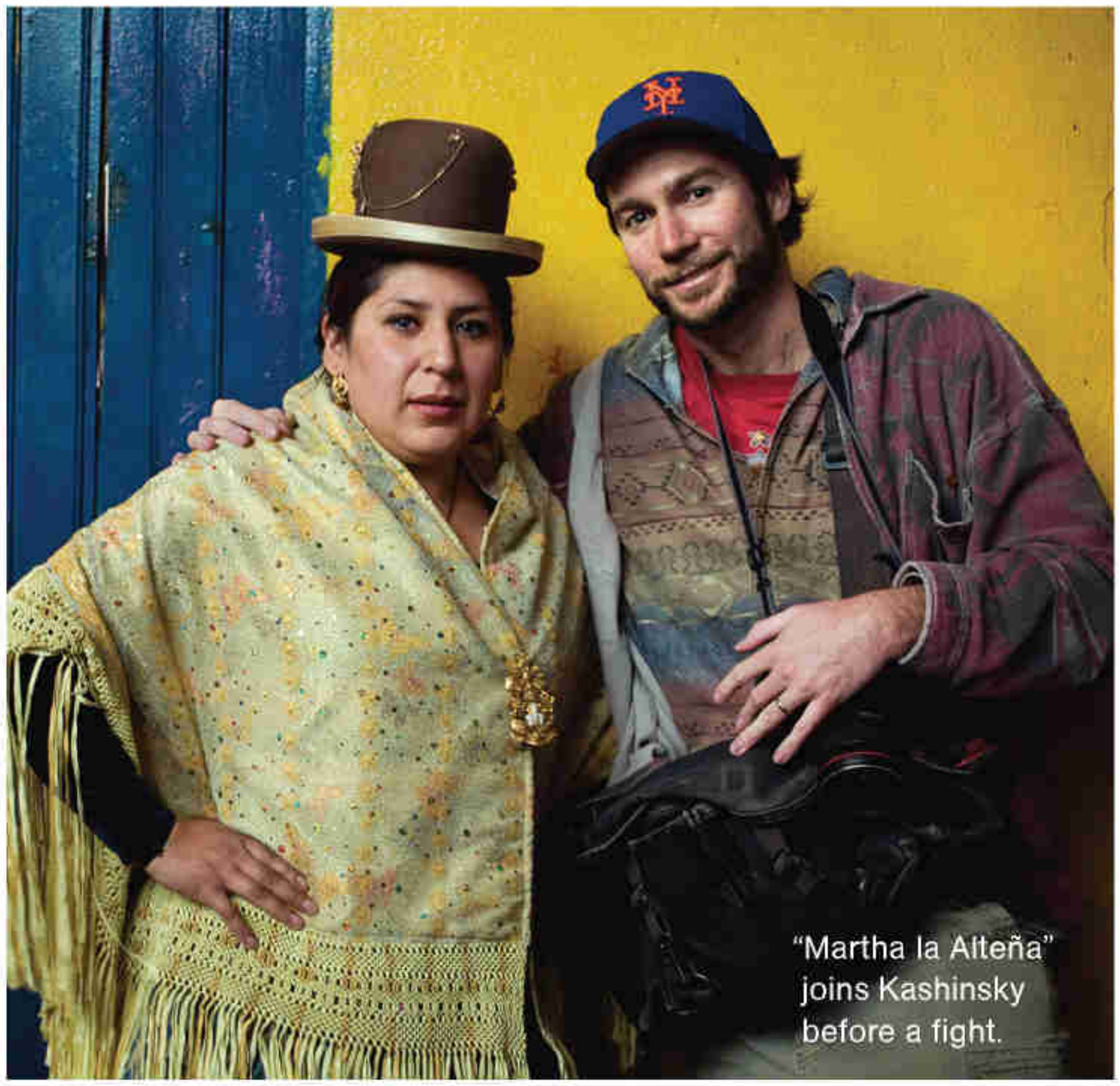
Relaxed Elephants

Nick Nichols took about 100,000 pictures of elephants in the six months he spent in Samburu last year. "You're just trying to be there when something interesting happens," he says.

He's covered African elephants for years, and says a lot of his images show aggression because of the animals' fear of humans. Not in Samburu. When he first drove up for the moonlight shoot (pages 50-51), the elephant family got up. "But then they lay down, one by one, right in front of the car."

PHOTOS: JIM RICHARDSON (TOP); MICHAEL NICHOLS, NG PHOTOGRAPHER

INSIDE GEOGRAPHIC



"Martha la Alteña" joins Kashinsky before a fight.

ON ASSIGNMENT **Fighting for Access** Getting women wrestlers to open their lives was tough, says photographer Ivan Kashinsky. "I kept calling Martha [above]. She'd say, 'I'm busy today, call Friday.' I'd call Friday, and nobody would pick up." On one trip to Peru with the wrestlers, their bus left without him. But gradually the women warmed, offering invitations to homes and introductions to families. "I was sorry to leave at the end," he says.

NG BOOKS **Pics in Space** The Hubble Space Telescope, launched in 1990, had a bumpy start. A flawed mirror blurred its vision. But it was soon fixed, and the telescope has been making brilliant images of the universe ever since. From its orbit above Earth's atmosphere, Hubble sees more clearly than telescopes on the ground. Its images, from the planets in our own solar system to ancient galaxy clusters billions of light-years away, are featured in the new book *Hubble: Imaging Space and Time* ($50). The authors explain how the instruments work, introduce the people who made Hubble possible, and look to the next space observatory, an infrared telescope set for launch in 2013.

PEOPLE BEHIND THE STORIES

■ **Charles C. Mann** While writing this month's cover story, "Our Good Earth," Mann, a journalist and author, learned what can only be described as an object lesson. "'Soil degradation' sounds so abstract," he explains. "It didn't truly sink in for me what it meant until I went to China. With Josh D'Aluisio-Guerrieri, who was translating for me, I walked down a long dirt road lined by farmers' houses—no electricity or running water. Here and there were lines of dead trees: failed windbreaks. Soon we came across some just harvested fields. Between the rows we could see that the soil was almost pure sand—they were growing corn in a desert. It was like trying to farm cement."

■ **Peter Gwin** After three sweltering weeks chronicling the excavations at the Sahara's biggest known Stone Age graveyard, Gwin, a *Geographic* staff writer working on this issue's "Lost Tribes of the Green Sahara," trekked to a lush oasis deep in the Aïr mountains. "I slept under date palms," he says, "ate pomegranates, figs, and tangerines off the trees, then swam in a spring-fed pool. It felt like a hidden paradise—until a boy wearing a frayed English soccer jersey approached and politely asked, in French, 'Sir, do you have any news of the great David Beckham?'"

PHOTOS (CLOCKWISE FROM TOP LEFT): KARLA GACHET; ROBERT CLARK; MIKE HETTWER

ESSAY CATEGORY **Larry Louie** Edmonton, Alberta
Photos of Tibetans in Gansu, China, impressed judges with the use of light.

A World of Photos

Get out your cameras: *National Geographic*'s annual International Photography Contest is accepting entries through October 31. English-language winners in three categories—People, Places, and Nature—will advance to the international contest, and each will receive a new camera. Two of 2007's English-language winning photos are shown here (left and below). Other winners from last year, and a selection of photographs submitted to this year's contest, are online now at *ngphotocontest.com*.

ANIMAL CATEGORY **Howard Sheridan** Fort Myers, Florida
Judges noted that this image mixed two Yellowstone icons—bison and hot springs—for a moody feel.

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If You Have a Home with Vermiculite Loose-Fill Attic Insulation

Your Rights May Be Affected by the W. R. Grace Bankruptcy

Your Claim Must Be Filed By October 31, 2008

W. R. Grace and its related entities ("Grace") have filed for protection under Chapter 11 of the U.S. Bankruptcy Code. If your home has vermiculite loose-fill attic insulation, you may have a property claim against Grace.

What Is Vermiculite Loose-Fill Attic Insulation?

Vermiculite was used by Grace in certain non-roll home attic insulation that was sold from the 1920/1930s to 1984. Some of Grace's vermiculite attic insulation contains naturally-occurring asbestos and was sold under the name of "Zonolite Attic Insulation" ("ZAI") and under other brand names, including: Attic Fill, House Fill, Home Insulation, Zonolite Insulating Fill, Econofil, Quiselle Insulating Fill, Sears Micro Fill, Ward's Mineral Fill, Wickes Attic Insulation, Attic Plus, Mica Pellets Attic Insulation, Unifil and Cashway Attic Insulation.

What Does It Look Like And Where Is It Located?

ZAI is an insulation product typically used in home attics and sometimes in walls. The granules are small, accordion-shaped nuggets and may have a silvery, gold translucent or brownish cast that may also appear black or gray over time. ZAI may be found underneath other insulation installed at a later date.

What Are ZAI claims?

ZAI claims could include, among others, the cost of abatement or removal, the diminution of property value, economic loss, or other property-related claims caused by ZAI manufactured by Grace.

Loose vermiculite

Vermiculite nugget size

To preserve your claim against Grace, you must file the Bankruptcy Court approved claim form by October 31, 2008. You may obtain the appropriate claim form and more information on how to file a claim by writing:

Claims Processing Agent, W. R. Grace & Co. Bankruptcy,
P. O. Box 1620, Faribault, MN 55021-1620 or

Call: 1-877-465-4817 or visit: www.graceclaims.com

FLASHBACK

Losing Ground A man measures the former ground level arm-high in rural Roosevelt County, New Mexico, in 1957. Only the deep roots of native bluestem grass held this hill of sandy soil together; winds had carved the rest away. Back then farmers here used clean tillage, the practice of clearing the soil surface of plant debris, says Patrick Kircher, a Roosevelt County agricultural extension agent. "They also broke down the ground to make a very fine seedbed. In country that's not very windy, that works well. But not here," he says. "Now we know to leave crop residue on the surface to help hold things in place." *—Margaret G. Zackowitz*

Flashback Archive Find all the photos at **ngm.com.**

PHOTO: USDA

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